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The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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The Exit from Industry

We have already referred to the attraction the raising of the school-leaving age has for those who see in it a means of breaking up in part the residue of unemployed. The other scheme which is advocated for the same reason is that of removing from industry all those over a certain age. The number of elderly people in the State continues to increase, and sooner or later it must be tackled as a problem. Every employer knows how difficult it is to discharge an elderly worker for whom no provision for old age exists, and hence we had about three-quarters of a million people gainfully occupied in 1931 over the age of 65, which is an age at which retirement becomes a practical proposition.

The report recently issued on this question by Political and Economic Planning suggests that a government wishing to encourage retirement at 65 can do three things. It might encourage and even assist workers to make their own provision for retirement. It might encourage schemes for retirement pensions by firms and public bodies. Thirdly, it might introduce a national pensions scheme, contributory or non-contributory, providing pensions for all employed persons conditional on their retirement.

The last mentioned scheme is considered the most practical, by extending the present Old Age Contributory Pensions Scheme so that an augmented old age pension would be payable to insured persons and their wives at 65, subject to retirement. A reasonable basis, on ground of administration and finance, is suggested as follows. An additional 10s. and 5s. a week should be given on existing contributory conditions to insured men and women respectively on retirement at 65. To facilitate retirement where a wife is younger than her husband, it is proposed that wives over 50 should be given a pension when the husband reaches 65, subject to both retiring. Single men and women could then look forward at 65 to pensions of 20s. and 15s. per week respectively, and married couples of 30s. when the husband reached 65. It is estimated that this would mean the retirement of between 300,000 and 500,000 elderly workers, and that places would then exist for 100,000 to 160,000 younger workers. The cost of the scheme is estimated roughly in the early years as about thirty millions, against which six to nine millions would be credited as savings in other directions, but as the number of elderly people increases the cost would naturally increase. If the augmented pension were met by equal contributions by employer, employed and the State, the share of the State in contributions of 9d. weekly would be eleven millions. Whilst such schemes are theoretically attractive the decline in population will by 1941, leave ample room for the retention of the older workers in gainful employment should they desire so to continue.

September

Foundrymen are anticipating an exceptionally busy period during the month of September. First of all there is the great engineering and foundry exhibition at Olympia. We are of opinion that this particular exhibition has more right to the appellation "Foundry Exhibition" than any of its forerunners, because of the blending of actual castings with foundry equipment and raw materials. At a rough estimate, at least fifty of the exhibitors possess their own foundries. Then, of course, there is the International Foundry Congress to be held in Brussels. Hereat there will be presented for discussion no less than thirty-two technical Papers, and nine works visits. There are to be meetings of the International Technical and Test Bar Committees, whilst on the social side there is a full programme of receptions and banquets.

Then, towards the end of the month, The Institute of Vitreous Enamellers is holding its second annual convention in London. The programme includes visits to the Engineering and Foundry Exhibition, and to the works of Belling & Company, manufacturers of electric stoves, cookers and other electric equipment, the annual dinner and a motor rally. There is to be a technical session at which two or three Papers will be presented for discussion.

In addition to the above, the Iron and Steel Institute is to hold a conference in Manchester, whilst Newcastle-upon-Tyne is to be the venue of the autumn meeting of the Institute of Metals. At both these manifestations a full programme of works visits and technical sessions have been arranged, whilst, as usual, the social side has been well catered for. *Force majeure*, a certain amount of clashing is inevitable, but granted a maximum measure of co-operation, the situation would not be materially ameliorated, as no one holding membership in all the Institutes could possibly afford the necessary time for participation in all. For the foundry executive, living in the provinces, it seems best that he should visit Olympia on his way to Brussels, and return in time to have a second look round the exhibition and participate in the vitreous enamellers' week-end congress in London, should he be interested in iron castings destined for domestic use or for corrosion- and heat-resisting purposes.

XUM

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

British Foundry School

To the Editor of The Foundry Trade Journal.

Sir,—We take this opportunity of thanking you for the sympathetic references in the "Journal" to the establishment of the British Foundry School and of reporting that the governing body require to have ten students to ensure the opening of the school in the early autumn. To date five applications have been received, and we understand that several others are pending. As the governing body, in making arrangements for the opening, must take definite steps during the present month, we should be very glad if firms contemplating sending members of their staffs, or any other students desiring to enter, would send applications as soon as possible.

We also find that some firms are waiting to see how the course develops before nominating students, but we would urge them to act forthwith to ensure the opening. Evidence comes to us daily of the urgent need in the industry for an organised course of this description, so that this country may be at least as well placed in this direction as France and Germany.—Yours, etc.,

R. G. Hosking,
Chairman of Governing Body.

J. G. Pearce,
Hon. Treasurer, British Foundry School,
August 10, 1935.

At a meeting of the holders of the 6½ per cent. registered notes of the Crittall Manufacturing Company, Limited, a resolution postponing the payment of these notes until a date not later than August 31, 1936, was unanimously approved.

Penton Medal Awarded to Canadian Foundry Owner

The Board of Directors of the American Foundrymen's Association announces that on the recommendation of the Board of Awards, it has awarded the John A. Penton Gold Medal of the Association to Major Lawrence Lee Anthes in recognition of distinguished service to the foundry industry of America. The presentation of the medal will be made to Major Anthes at the time of the Association's Annual Dinner, held at the Royal York Hotel, Toronto, Canada, during the week of the 39th Annual Convention.

Major Anthes has long been actively connected with the work of the American Foundrymen's Association, having served as Vice-President in 1906-1907 and as President in 1908-1909. In addition, he has served on many committees and for several years on the Board of Directors.

He was born in Toronto on November 26, 1876, and entered the service of the Toronto Foundry Company, in 1896, joining his father in the manufacture of cast iron soil pipe and fittings. In 1899 he left the foundry business temporarily to enter the field of journalism, but rejoined the Toronto Foundry Company, Limited, in 1902 in the capacity of superintendent. The name of the firm was changed to the Anthes Foundry, Limited, in 1908. Through the efforts of Mr. Anthes, the company extended its business and erected a soil pipe plant in Winnipeg in 1912. Major Anthes became managing director and secretary-treasurer of the Anthes Foundry, Limited, at Toronto and Winnipeg, in 1914.

During the Great War he was connected with the Canadian Expeditionary Forces from 1916 to 1918, with the rank of Major. He was appointed Director of the demobilisation branch of the Department of Soldiers' Civil Re-establishment in November, 1918, assuming responsibility of repatriation of Canadian Overseas Forces. He continued in this capacity until

(*Concluded in next column.*)

(*Concluded from previous column.*)

June, 1920. Since his war activities, Major Anthes has devoted his time to various industrial and civic organisations. In addition to his position as President of the Anthes Foundry, Limited, Toronto and Winnipeg, which he assumed in 1933, he is chairman of the Board of Anthes-Tait Foundry, Limited, Vancouver, B.C., President of Imperial Iron Corporation, Limited, St. Catharines, and President of the Lennox Furnace Company of Canada, Limited.

Major Anthes served as Chairman of the Industrial Relations Committee, Canadian Manufacturers' Association in 1932-33, and as Vice-President (1932-33), and as President in 1933-34. At present he is first Vice-President of the National Construction Council of Canada, and on the Advisory Board of the Canadian Construction Association. During this past year he has served as Vice-President and chairman of the Constitutional Committee of the Canadian Institute of Plumbing and Heating.

JOINT AUTHORS OF "CASTINGS"

Mr. W. Machin.

Mr. M. C. Oldham.

Mr. W. Machin and Mr. M. C. Oldham are the joint authors of the Paper on "Castings" which was presented to the annual meeting of the Institute of British Foundrymen at Sheffield. This Paper, which will be one of the longest and most informative ever published in The Foundry Trade Journal, begins on page 115 and will be continued in several succeeding issues.

Book Review

Enamels—The Preparation, Application and Properties of Vitreous Enamels. By Andrew I. Andrews, Ph.D. Published by the Twin City Publishing Company, Champaign, Illinois, U.S.A. Price $5.50.

The reviewer can sincerely endorse the commendations made by the Fellows of the American Ceramic Society and the Porcelain Enamel Institute of America, in so far that this publication is in his opinion the most comprehensive survey of all the processes involved in enamelling cast- and sheet-iron ware.

The simplicity with which the most technical expositions are set out renders it most advantageous for the students, whilst the technical and practical side is equally well blended, so that the book can be regarded as a first-class reference to the ceramic chemist and to the jobbing enameller, and represents an ideal textbook for the student.

Typical of the accepted American foundry practice, the reviewer finds that low silicon and phosphorus cast irons are recommended, and the author further suggests the utilisation of the middle of the melt only for enamelling purposes. This is worthy of exploitation by British plants.

The chapter on the preparation of metals for surfaces is particularly sound, setting out as it does the theory of cleaning and pickling, the composition and maintenance of pickle baths, and the practical aspects of blasting, using sand or steel abrasives as a medium.

It is to be regretted that the author did not see fit to show comparisons in regard to the various processes, but it must be admitted that as each one is so fully described, deductions are made with comparative ease. There is one important omission, and that is the use of trichlorethylene degreaser, the adoption of which has spread very rapidly in recent years in this country.

The process control methods of enamel slip as outlined are sound, as are the tests on the finished ware for adherence, expansion, hardness, etc. Here again one feels that the author would have earned still further appreciation from the trade had he recommended certain standards to which first quality enamellers should conform. It may be that he considers the determination of standards is a question for The Porcelain Enamel Institute in America and The Institute of Vitreous Enamellers in this country, and the reviewer hopes that both associations will take due note.

Such subjects as milling, spraying, furnaces and fusing, and even the variation of sand-blast nozzles are fully dealt with, and will unquestionably be of practical assistance to all concerned in the control of such processes.

W. T.

The Determination of Moisture in Moulding Sands

By S. E. DAWSON, F.I.C., and F. T. HANKS

In view of the important part played by the water or moisture content in sands in the foundry, much investigatory work has been done with a view to arriving at some quick yet reliable method for its determination to replace the usual laboratory method of loss by weight which for most foundry requirements is somewhat lengthy in arriving at a useful result.

Such work has resulted in several types of instruments being evolved which merit certain advantages in their particular application, but it was felt by the authors that a study of the subject might well be made based on the conductivity of the moistening medium in a similar

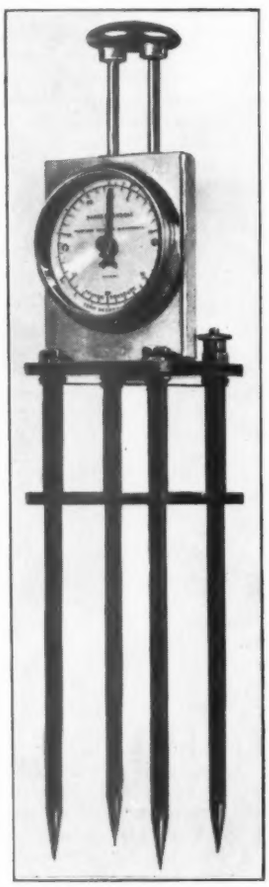


FIG. 1.—NEW MOISTURE DETERMINATION APPARATUS FOR MOULDING SAND.

manner to the dionic testing of water, where the percentage of conducting matter in the water may be determined by electrical measurements when suitable compensation for changes of temperature is made.

In such tests distilled water is taken as being practically a non-conductor and any salts in solution being measured by the increased conductivity, due allowance—about 2 per cent. per degree centigrade—being made for variation in the temperature of the water. In a similar manner it was thought that dry sand might be considered in the same light as distilled water, that is a non-conductor, and that any conductivity due to the moistening water might be measured by the same means.

In carrying out a series of tests by adding known amounts of tap water to a sand, it was found that, under certain standardised conditions, the percentage of added water could be verified by this method. Such conditions effecting the conductivity were found to be the *density* and *temperature* of the sand, and it was necessary to introduce in the apparatus, as described below, means to compensate for these factors which may vary with the particular mass of sand under test.

The apparatus* used and as shown in Fig. 1. consists essentially of a special form of electrodes, used in conjunction with an ohm-meter and suitable battery, the electrodes being so designed as to get most contact with the mass to be tested. The electrodes are provided with four stems and spikes, the stems being of convenient length to cause the conically formed spikes or contacts to penetrate the mass under test to any desired depth. The electrodes are cross connected, thus causing the whole circuit to be balanced. This arrangement overcomes to a large extent the effect of electrical changes which take place when current passes in one direction only, so causing unsteady readings on the instrument.

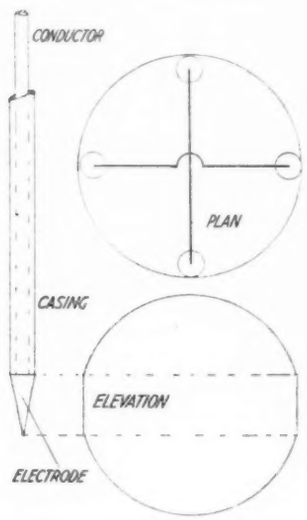


FIG. 2.—SHOWING ELECTRODE ARRANGEMENTS.

By disposing the four electrode stems as at the corners of a square, the mass of sand subject to current paths is roughly of spherical form elongated vertically in the centre of a zone equal to the length of the electrode points, as is shown diagrammatically in Fig. 2. The spacing of the electrodes was not found to be critical, so that the separation was fixed to suit the scaling of the instruments as well as the capacity of the sand container or box, which must necessarily be of wood or other non-conducting material.

Density

In connection with the early tests, it was found that in any bulk of sand, the density increase from top to bottom had an appreciable effect on its electrical conductivity. This is readily seen in the "density curve" shown in Fig. 3, which was obtained by taking conductivity readings at different depths in a mass of sand which had been "dumped" so as to reduce the depth by about 10 per cent. from the loose condition. It will be seen from this graph that the conductivity increases progressively as the density increases.

* Patent Application No. 14602/34.

To standardise this by endeavouring to obtain a constant density material or reach a fixed density strata was not found to be practicable, but by causing the electrode spikes to penetrate the sand under a *definite pressure*, then a prearranged standard density was automatically found in all tests. An arrangement was therefore embodied in the instrument whereby a known pressure could be applied by hand and operate through a spring on to the top side of the penetrating electrodes. An index finger operated by the spring and moving over a circular scale served as an indicator of such pressure.

Fig. 4 shows the results of conductivity tests on the same sand dumped as before, but taken at different densities obtained by increasing pressures applied on the electrodes and irrespective of depth. This device also overcame the necessity of any accurately-standardised packing of the sand or the preparation of a special test block, the "dumping" referred to being sufficient to get regular distribution for the heat. Further tests were then carried out on the same

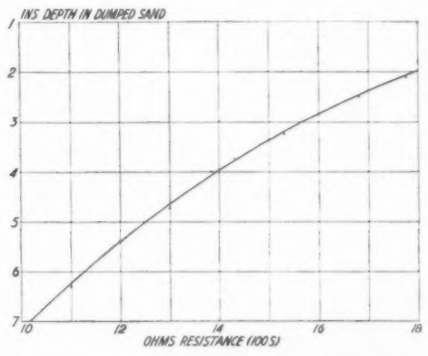


FIG. 3.—SHOWING VARIATION OF ELECTRICAL CONDUCTIVITY WITH DENSITY.

sand by dumping to increasing extents, when, under a pressure (15 lbs.) on the electrodes the conductivity readings for equal moistures were substantially the same, although the depth of

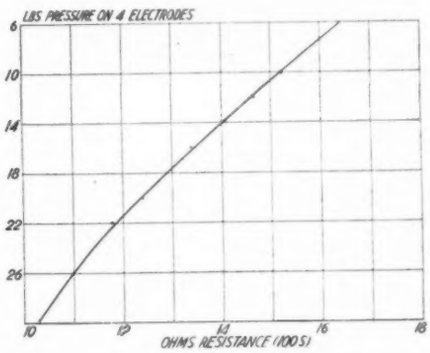


FIG. 4.—SHOWING RELATION OF ELECTRIC CONDUCTIVITY TO ELECTRODE PRESSURE.

penetration varied considerably, thus proving that the electrodes had found an equal density under the same load.

Temperature

The effect of temperature on conductivity is seen in Figs. 5 and 6, which show the results of a series of tests on a sand, the one under constant temperature with increasing amounts of water added, and the other of constant moisture content and increasing temperature. In the first case (Fig. 5) suitable precautions were taken to ensure the temperature being constant during the test, and any variation due to density was obviated by working under a pressure of 15 lbs. throughout, so that the value in ohms could have been transcribed or calibrated into degrees of

moisture. As a check, the actual percentage of moisture was taken by the usual laboratory method at the time of each test.

In the second case (Fig. 6), that is, constant moisture content but rising temperature, due

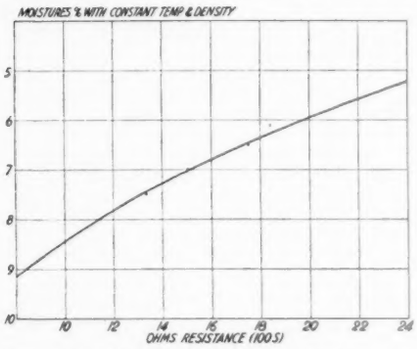


Fig. 5.—Moisture Content Related to Conductivity when Temperature and Pressure are Constant.

precautions were taken by sufficient depth of penetration (4½ in. under a 20-lb. load) to avoid loss of moisture at the point tested. The tests were conducted in a humid atmosphere and the period of each increment of heating sufficiently long (2½ hrs.) to ensure the measured temperature being thoroughly attained.

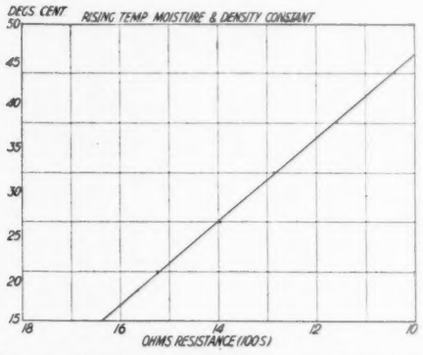


Fig. 6.—Conductivity Related to Increasing Temperature, but with Constant Density.

From the foregoing series of tests it will be seen that the conductivity of a mass of sand increases with increased temperature and density so that, co-relating these two factors, by testing in a lower density for the higher temperatures and *vice versa*, a ready means of compensation for temperatures is available.

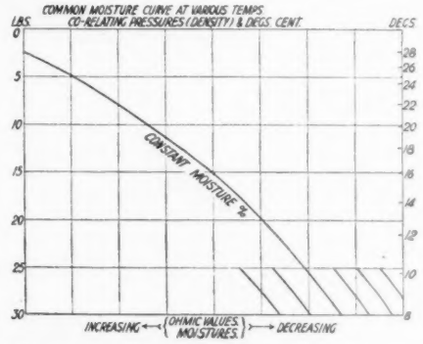


Fig. 7.—Moisture Content Curve Derived from Correlating Previous Data.

This is comparable with the principle adopted by Messrs. Eversheds & Vignoles in their Dionic water tester, in which changes of temperature are compensated for by measuring through a column of liquid whose length is varied by and adjustable electrode, the required length being determined by the temperature at the time of testing.

From the various tests carried out in the manner indicated, the exact relationship between temperature and pressure was obtained, and the pressure gauge on the electrodes spaced out in terms of temperature degrees, so that by first ascertaining the temperature of the sand by an ordinary thermometer and the corresponding pressure being applied, the percentage of moisture is read directly from the ohm-meter, which is suitable calibrated in those terms.

The co-related figures as applied to the apparatus are shown in Fig. 7, which covers a temperature range of 20 deg. C. (36 deg. Fah.), corresponding to a total pressure variation of 27.5 lbs. The curve on this graph indicates a uniform moisture content against the varying temperature of the mixture on test. Similarly, a uniform ohmic value, if the measuring instrument is calibrated to a resistance scale. Curves of different moistures would be indicated by others running (wavelike) parallel to that shown. It has been observed during the experiments that, at the lesser densities, less pressure is required to bring about the necessary condition to compensate for, say, one degree change in temperature than is the case at the higher densities. This accounts for the diminishing temperature scale and consequent flattening of the moisture curve at the end corresponding to the higher temperatures.

Publication Received

Institute of Mechanical Engineers. Brief Subject and Author Index of Papers in the Proceedings, 1847-1934.

To boil down to the compass of 140 pages the indexing of subject matter and authors in 87 years of the Institute's Proceedings is, indeed, an achievement. The problem has been very intelligently solved by incorporating initially half-a-dozen pages of cross references. A typical sort of reference is "Cast Iron, See Foundry Practice and Iron," and on referring to, say, the former, the page number is given as 64. This is followed by another key to the subject index. It absorbs a further 32 pages. A typical reference in this section is "Pearce, J. G., See Foundry Practice, 1925." On referring to this heading in the third section—the headings are arranged alphabetically—we find that Mr. Pearce wrote on "Cast Iron and Modern Engineering Practice." The 1925 is a guide, as the Papers under each section are listed chronologically. It is interesting to note that no other Paper has been listed on this subject since that date. Yet under "Iron and Ironmaking," at which section we are instructed to inspect, there has been a further Paper by Donaldson on "Thermal Conductivity of Cast Iron" in 1928. Furthermore, we believe we are correct in stating that there has been a contribution this year by Hurst. We have made this comment because there was an eleven-year interval prior to Pearce's Paper without a single reference to either cast-iron foundry practice or cast iron. The increasing frequency of references since 1925 is unquestionably a matter of satisfaction for the foundry industry. It is a very useful work of reference and a real service to the members.

Free-Cutting Aluminium

A new series of free-cutting aluminium alloy is reported from America. These new alloys, it is claimed, offer many opportunities for the economical production of parts for a wide variety of structural assemblies. They are resistant to tarnish and corrosion. Very high yield, tensile and shear strengths are obtainable and the alloys compare favourably with duralumin and free-cutting brass.

Iron and Steel Institute

AUTUMN MEETING AT MANCHESTER

The autumn meeting of the Iron and Steel Institute will be held in Manchester on Monday to Thursday, September 16 to 19. The President (Sir H. C. H. Carpenter, F.R.S.) will preside. A Reception Committee, representing the iron, steel and engineering industries of Manchester and Lancashire, has been formed, and of this the Rt. Hon. the Earl of Crawford and Balcarres, P.C., K.T., is the President, Mr. J. E. James the chairman, Alderman F. J. West the hon. treasurer, and Mr. H. D. Lloyd the hon. secretary. The Committee includes representatives of works on the Cumberland Coast to which invitations to pay visits have been received.

The sessions will be held at the Manchester College of Technology. The subsequent arrangements include visits and excursions to the principal iron and steel manufacturing and engineering establishments in Manchester and district, and social entertainments.

The following is the complete list of Papers to be presented at the meeting:—

(1) "Sixth Report on the Heterogeneity of Steel Ingots" (Special Report No. 9).

(2) "Waste-Heat Boilers in Open-Hearth Practice" (Special Report No. 10).

(3) E. W. Fell: "The Piobert Effect in Iron and Soft Steel."

(4) E. T. Gill and R. Goodacre: "Some Aspects of the Fatigue Properties of Patented Steel Wires. II.—Note on the Effect of Low-Temperature Heat-Treatment."

(5) W. E. Goodrich: "The Penetration of Molten White Metals into Stressed Steels."

(6) R. H. Greaves: "The Properties of Some Low-Nickel Steels containing Manganese."

(7) R. Griffiths: "Subcutaneous Effects during the Scaling of Steel."

(8) A. M. Herbert and F. C. Thompson: "The Use of the Hele-Shaw Apparatus in the Investigation of the Flow of Metals."

(9) W. E. Hoare and B. Chalmers: "Examination of the Surface of Tinplate by an Optical Method."

(10) C. H. M. Jenkins: "Behaviour of Mild Steel under Prolonged Stress at 300 deg. C. Part II—Experiments on Concentrated Stress in Notched and Drilled Specimens."

(11) C. H. M. Jenkins and G. A. Mellor: "Investigation of the Behaviour of Metals under Deformation at High Temperature. Part I.—Structural Changes in Mild Steel and Commercial Iron during Creep."

(12) E. Maurer and W. Bischof: "The Distribution of Phosphorus between Metal and Slag in the Basic Process of Steel Manufacture."

(13) A. M. Portevin and R. Castro: "The Morphology of Inclusions in Siderurgical Products."

Tuesday, September 17.

General Meeting in the Grand Hall of the Manchester College of Technology. Welcome to the Institute by the Lord Mayor of Manchester, and the President, chairman and members of the Reception Committee. It is expected that Papers (1) and (4) will be discussed.

Wednesday, September 18.

General Meeting in the Students' Common Room of the Manchester College of Technology. It is expected that the following Papers will be discussed: Nos. (8), (2) and (11).

Metal Surface Protection

Portland cement reground to the fineness of a pigment, pure linseed oil and tinting pigment form the basis of a coating for the protection of structural and other steel surfaces exposed to atmospheric corrosion. The cement pigment, it is claimed, changes the iron oxide to ferric calcite.—"Steel."

Castings*

By W. MACHIN and M. C. OLDHAM

It is the authors' intention in this Paper to make the various points on castings manufacture as practical as possible. It is thought by dealing with the matter on these lines many of those associated with the craft will better understand the points raised, and thus influence them to give closer attention before the pattern is put into the sand, thereby eliminating many of the defects seen in castings. So many variables are associated with the manufacture of castings that the degree of success obtainable depends mainly on the decisions made by those responsible for the methods of procedure. The variables referred to concern work on moulds and cores, materials and metallurgical processes.

The predominant factors, therefore, to obtain successful production are experience, coupled with careful thought and study, before commencing manufacture, and a definite line of co-operation with those concerned on the metallurgical side of the industry. Every design presents its peculiar problem, more or less, in that the casting has to comply with the exacting clauses of modern specification and inspection relative to the particular service required from it as a finished product. Progress is being made only by the close co-operation of designer, patternmaker, moulder, coremaker and metallurgist, and there has been evident, during recent years, an increasing tendency to establish this collaboration in the foundry. The generally accepted excellence of castings now being produced may be attributed to such co-operation.

Castings have to be supplied in accordance with the designer's conception of what is essential to meet the requirements of service, and, modern construction specifying minimum weight, exhibit variations in thickness of an astonishing nature. The disposition of masses of metal at local junctions is a feature of present-day design, and frequently it is necessary to consult the designer to suggest some modification here or there to assist the foundry. Invariably the suggestions put forward and accepted do ease the problems, but, generally, due to the light sections in which modern castings are designed, chiefly arising from the improvement of materials, modifications suggested by the foundry cannot always be accepted in full, though as much as possible is done to meet them. Problems are surmounted only by most thorough investigation over the entire range of manufacture.

* A Paper read before the Annual Meeting of the Institute of British Foundrymen at Sheffield. The Authors are associated with the Barrow Works of Vickers-Armstrongs, Limited.

Variable Thicknesses

Thicknesses vary considerably in modern structural design, in some instances from 1 to 20 in. The variations shown in the steel casings and valves required for temperature and pressure service in land turbines, range from 1½ to 14 in. Steel castings for marine-engine turbines, range in thickness from ½ to 3 in., and for service in gun mountings, the thicknesses range from ¼ of an in. to 3 in.

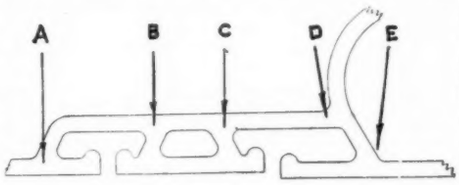


Fig. 2. — Changing Thicknesses are seen at Junctions lettered A, B, C, D, E.

Intricacy in design, with its inseparable variations in thickness, presents a problem, on the solution of which depends the production of castings to meet the requirements of modern engineering.

Numerous drawbacks may be involved in the manufacture of the mould, and most thorough examination of thicknesses is vital. There must be definite assurance that the mould and core surfaces will withstand the impact and wash of molten metal, and the mould has to be so constructed as to offer no resistance to contraction. The composition of the metal, and efficient mixing and melting of the diverse alloys in present-day use, call for expert metallurgical supervision.

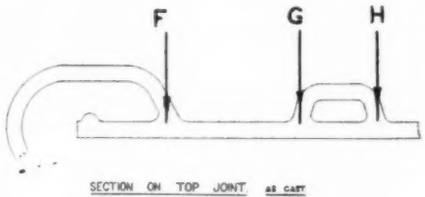


Fig. 3.—Changing Thicknesses are seen at Junctions lettered F, G, H.

Patternmaking

Following the receipt of the designer's blueprint, experience and skill of the highest order is necessary in the manufacture of the pattern, in accordance with the requirements of the foundry, if castings of first-grade quality are to be efficiently produced on economical lines. The co-operation of the foreman patternmaker is therefore necessary, so that the pattern can be made in accordance with the method adopted by the foundry, thus facilitating the moulding, coremaking, running and feeding arrangements. The methods of making patterns vary in accordance with the different metals in which the castings are required, viz., steels, irons and the numerous non-ferrous alloys. The method of feeding a steel casting differs entirely from that of iron, but a few of the irons and non-ferrous alloys are similar, viz., Lanz Perlit and Emmel irons, alloy irons and some of the bronzes or brasses.

A pattern for use in a steel foundry requires the most consideration, as steel contracts more than iron or brass, and the casting temperature is higher, with earlier commencement of the freezing stage. In addition, shrinkage, consequent on the cooling of thick sections, has to be made good by a flow of liquid metal, from what are known as feeders, risers or heads. The pattern must be constructed in a manner which will enable the foundryman to cast his mould in the correct position, thus permitting him to place the feeders over those parts where changes in thickness occur in the casting. Some illustrations of this point will be interesting.

Fig. 1.—Pattern of a Cast-Steel Bottom-Half Turbine, set in Casting Position.

Fig. 4.—Shows the Feeders for a Turbine Casting.

Methods of Running

Note that the pattern shown in Fig. 2 is placed in position with the joint face uppermost in order that feeders can be placed over those parts where three lanes of metal meet at A, B, C, D and E. The same point is illustrated in the sketch at F, G, H in Fig. 3

The feeders used over these parts of the casting can be seen in Fig. 4, showing the actual casting being dressed, whilst Fig. 5 shows the reverse side of the casting shown in Fig. 3—the side of the casting would have been uppermost had it been made in iron, an instance of the importance of co-operation between the patternshop and the foundry.

The methods of running and feeding vary considerably, and in this connection the first report published in 1933 by the Steel Casting Committee of the Iron and Steel Institute, was extremely illuminating in its disclosure of the variety of methods adopted by founders. The report on the various castings made from the one design

for the purpose of that investigation plainly indicated that each separate method adopted resulted in failure. Had information been available as to the exact detail of the separate methods under which those castings were made, the sands used in the manufacture of moulds and cores known, useful criticism might have been offered by many of those interested. The illustrations of the report referred to indicated that the methods of running and feeding were, in most cases, not those likely to succeed.

This was the opinion of many of the founders turning out steel castings for pressure work, and such being the case, a more general discussion from the practical side might have assisted further investigations on the same subject. The methods of running and feeding the different metals vary considerably. It is considered that the feeder giving the most satisfactory results is one just large enough to be effective, the dimensions varying with the shape and thickness of the section to be fed, with easy tapers preferable. The centre of the thickness of metal being the part required to be fed, should be the point to receive the centre of the feeder, as that is invariably where shrinkage occurs.

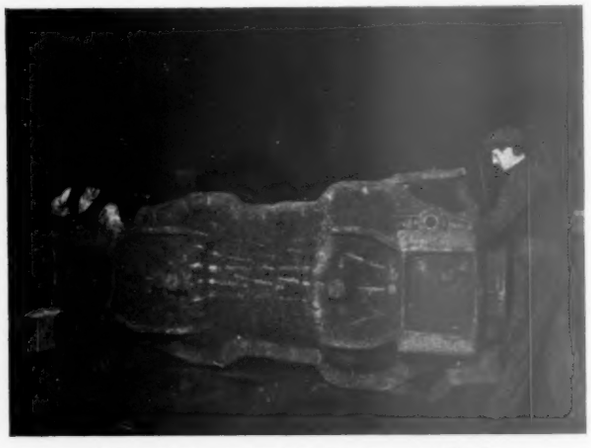


Fig. 5.—Shows the Reverse Side of Fig. 4.

Shrinkage

Shrinkage can be dealt with under three headings:—(1) Contraction in volume of the liquid metal from the temperature at which it is cast, to that at which it is just on the point of solidification; (2) contraction in volume in passing from the molten state at freezing point to the solid state at freezing point; and (3) contraction in volume from the point of actual solidity to normal temperature, this being the contraction shown on the patternmaker's rule. The defects due to inefficient feeding come under headings (1) and (2), and hot tears under heading (3).

In order to demonstrate the different methods under which a number of steel castings of exactly the same design were actually fed, three illustrations, shown separately in Figs. 6, 7 and 8, will be interesting. explained in detail.

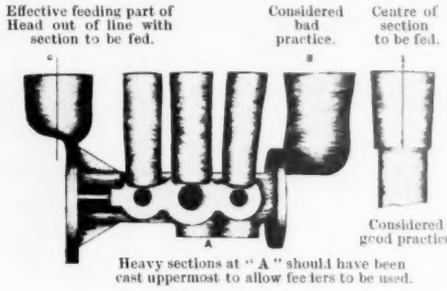

Effective feeding part of Head out of line with section to be fed.
Considered bad practice.
Centre of section to be fed.
Considered good practice.
Heavy sections at "A" should have been cast uppermost to allow feeders to be used.

Fig. 6.—Feeding Details.

In Fig. 6, A shows how the job has been moulded, with the heavy sections in the lower half of the mould, thereby eliminating the feeding; B shows a very unsatisfactory type of feeder, used no doubt owing to easy removal in the dressing shop and cutting out extra work. This type of feeder is considered too bulky, and is unsuitable as regards position, owing to it not being placed directly over the part to be fed; the correct method of using a round feeder of this description will be observed on the right-hand side of Fig. 6; and C shows the same type of feeder used on the top of the flange in a position considered good practice, but it will be noted that the centre of the feeder is out of line with the centre of the flange. As the centre of every feeder is obviously the last part to solidify, it follows that it is the most effective feeding part. The shape of the feeder "C" is also too bulky and will bring about too much heat in its vicinity.

In Fig. 7 is seen another idea of feeding; it shows five feeders at C of very unsatisfactory design, as they are too small, the portions at A and B being insufficiently covered. In addition, the feeders have no taper as that shown at D, which is considered a correct design to use on a steel casting of this type. It will be observed that the centre of this feeder covers the centre of the part to be fed, and also the feeder D is not too bulky, being of gradual taper.

Fig. 8 shows another idea of casting the same job in a vertical position, and feeding is done in quite a different manner. This method is also unsatisfactory, owing to side feeders being employed on the flange cast at the bottom. Feeding cannot be effectively carried out in this manner, and the arrangement is not a good one from the point of view of contraction. The feeder used at B is of a plain tube type, and the core was carried through at full internal diameter size of the casting. In this instance the portion requiring to be fed, is not so effectively covered as that shown at C, which is considered correct, the centre of the feeder leading directly into the thick part, where the flange joins the body of the valve. The feeder shown at A is also considered a better type to use were the same job cast in solid form.

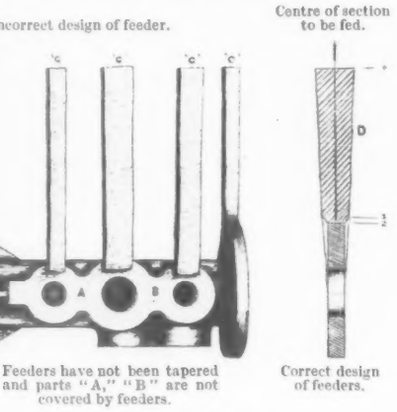

Incorrect design of feeder.
Centre of section to be fed.
Feeders have not been tapered and parts "A," "B" are not covered by feeders.
Correct design of feeders.

Fig. 7.—Feeding Details.

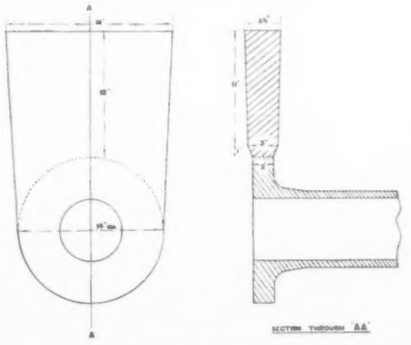


Fig. 9.—Feeder on Valve Flange.

It will be noticed that feeder A is tapered from 6 to 8 in., and is placed over the centre of the casting. The shrinkage, therefore, taking place from the 6-in. dimension, is well covered and made good by the extra bulk of metal in the taper to 8 in.

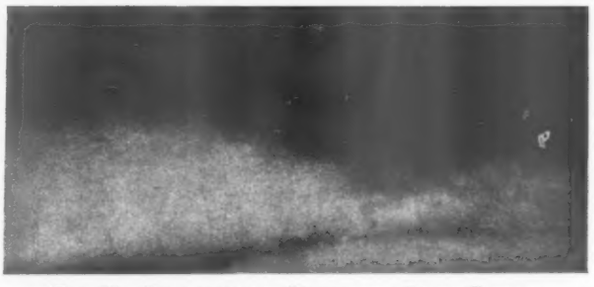


Fig. 10.—Radiograph of Defect in a Steel Casting.

Fig. 9 illustrates a feeder considered to be the correct type to use on a valve flange. The effective method by which the flange and fillet are fed are noteworthy, as they do not localise the temperature unduly.

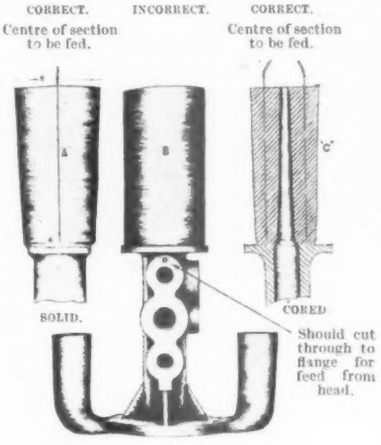


Fig. 8.—Feeding Details.

The shape of the feeder with its generous height, necessary to hold up the bulk of metal in the body of the mould, thereby affording the desired gravity pressure, is also good practice. The running of moulds for steel castings needs to be carried out in a manner to ensure a supply

of hot metal in close proximity to the feeders, as near to the top of the mould as can be conveniently arranged. It has been found in practice that the most satisfactory results are obtained by this method, assuming all other conditions in the mould are suitable.

Unless the running arrangements and general conditions referred to are carried out satisfactorily on the lines described, shrinkage cavities of a type well illustrated in the radiograph shown in Fig. 10 will result. This effectively shows the shrinkage defects which can develop at junctions where three lanes of metal meet, as shown in Figs. 2 and 3.

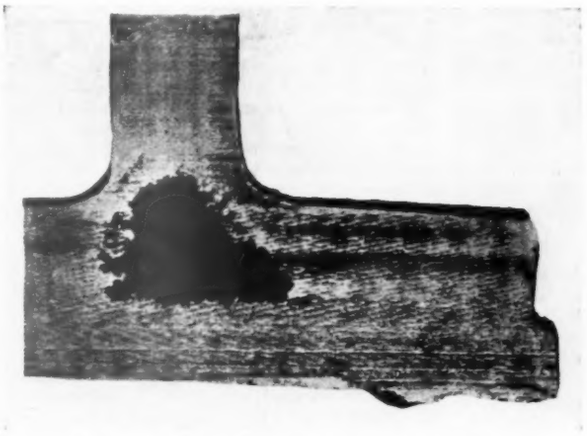
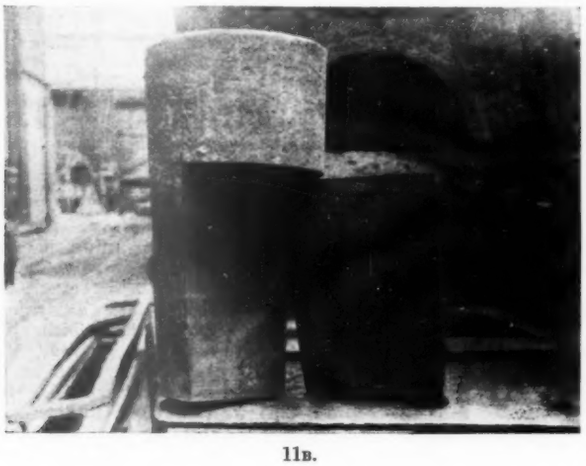


Fig. 11.—The actual Defect disclosed by the Radiograph (Fig. 10).

Fig. 11 shows a section cut from the casting, and the shrinkage cavity illustrates the actual defect disclosed by the radiograph (Fig. 10). Any position at which feeders may be placed can never be satisfactory unless hot metal can be supplied to them, and obviously the runner or runners must be placed in position to ensure such supply. To illustrate this point more clearly, two photographs, Figs. 11A and 11B, of a sectioned feeder taken from a casting which was bottom-poured, should be of interest. Fig. 11A shows the feeder with shrinkage at the bottom



11B.

portion of the casting, and Fig. 11B illustrates how solid the metal is in the upper portion. It will be appreciated, therefore, how important it is that the hottest metal should be in the feeders at the finish of the casting operation.

A method brought into use where possible, is that of adding hot metal to the feeders by means of the ladle, after the mould has been cast. This practice is good, but not always convenient over a large number of feeders. In addition, it frequently delays other operations, such as the quick break-up of the mould before the easing operation is commenced. The correct and more reliable method of feeding and running a casting may not be adopted by the founder, owing to the cost involved in that particular method. Risks may be taken to get a job out on price and another method selected, the expenses connected with which may promise a margin, but more often than not the procedure results in inferior-quality castings being produced.

The adoption of methods entailing efficient feeding and running may be more definitely observed in those foundries where pressure castings are manufactured. Steel castings of high quality cannot be produced, unless the supervisor provides facilities for satisfactory feeding, and running, before the making of the mould.

Some illustrations, Figs. 12 to 18, of the extra moulding work necessary in the making of moulds to obtain such facilities present material of interest.

The mould shown in Fig. 12 has had to be made with a number of loose pieces, or drawbacks, to obtain good running and feeding conditions. The first drawback has been inserted, also the prints to receive the steam-passage cores in the large core at the rear can be seen, the cores as shown in Fig. 12 having been removed to illustrate this.

It would have been much easier to mould this job the reverse way, as would have been the case in iron, as feeding and running arrangements would have been entirely different. The sections of metal which must necessarily be fed, such as those that vary considerably, encircling the bearing cores, and those around the core which form the steam passage are noteworthy. At these parts, sections similar to those in Figs. 2 and 3 exist.

Ample provision has to be made to ease the casting quickly. The top half of the mould is so constructed that the moulding box can be expeditiously taken off, to allow easy access for further removal of loose pieces and other parts, which would otherwise retard contraction. Similar methods have been employed and a large quantity of loose pieces have to be allowed for in order to facilitate correct running and feeding.

(To be continued)

11A.

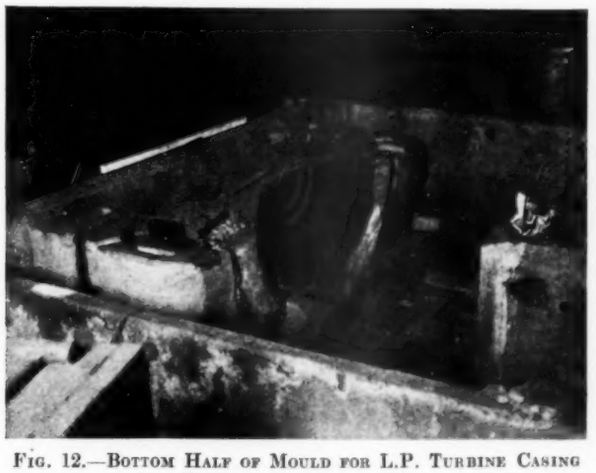


Fig. 12.—Bottom Half of Mould for L.P. Turbine Casing showing the Bearing Side being Cast uppermost.

Locomotive Factory in India?

The question of starting a factory in India for the manufacture of railway locomotives was discussed at a meeting of the Standing Finance Committee for Railways held at Bangalore, when the sanctioning of the rolling-stock programme was being considered. The Financial Commissioner agreed with the object, but observed that it would take at least two years to equip an Indian factory. The question was already being considered by the Government. The Commissioner assured the Committee that in the meantime it would be made a condition of all contracts placed for locomotives with concerns in foreign countries that they should admit some Indian apprentices to their workshops.

Orders to the value of £265,000 are being placed with British firms by the Chinese Government for rolling-stock for the Canton-Hankow Railway, according to a message from China.

D

XUM

New Data on Ingot Mould Life

LACK OF MANUFACTURERS' CO-OPERATION DEPLORED

The Paper which received the most consideration at the Sheffield Convention of the Institute of British Foundrymen was that on "Ingot Mould Life," by Dr. Swinden and Mr. G. R. Bolsover. This was well deserved, as a vast amount of valuable data was disclosed, both in the Paper and during the discussion which followed it.

DISCUSSION

Ingot Mould Manufacturers Rebuked

Dr. W. H. Hatfield, F.R.S. (Brown-Firth Research Laboratories), who was asked to open the discussion, congratulated the authors on their excellent Paper and expressed the general appreciation of the generosity with which the United Steel Companies, Limited, had enabled them to give the results of a very careful and critical examination of the whole question of ingot moulds in their works. Dr. Swinden and himself, he said, were respectively chairman and vice-chairman of the Committee on the Heterogeneity of Steel Ingots, which was a national committee representing the Federation of Iron and Steel Manufacturers and the Iron and Steel Institute. They were of necessity following up this subject of ingot moulds in a most thorough and technical manner on behalf of the industry, and he wished to emphasise how generously one of the biggest steel concerns in the country, if not *the* biggest, was making its data available in the Paper. The firms with which Dr. Swinden and himself were associated represented between them nearly 25 per cent. of the monetary value of steelmaking in this country.

Having inquired whether there were present at the meeting any principals of firms engaged in the manufacture of ingot moulds, and having received no response, Dr. Hatfield said he would like the Press, and particularly the technical Press, to state that no ingot-mould manufacturers were present, even though the authors had prepared their Paper at such great pains and with such serious purpose for the benefit of the metallurgical industries. It was reprehensible.

Dr. Hatfield then asked how many of those present at the meeting were concerned with the manufacture of ingot moulds, and he received a response from six; but he disqualified Mr. John Shaw, who was at one time concerned with the manufacture of ingot moulds, but is not directly concerned to-day, so that the total was reduced to five. It was a serious matter, he said, that when so important a Paper was presented on the subject of ingot moulds at the annual conference of the Institute of British Foundrymen in Sheffield, which city was the centre of the special steel trade, there should be only five gentlemen present who were concerned in the manufacture of ingot moulds. It meant that this very definitely practical problem before the steel trade was having to be tackled by the steelmakers and not by the mould makers. He personally appreciated more than he could say the generosity with which the United Steel Companies and the authors of the Paper had come forward with information. He confirmed also that the Federation of Iron and Steel Manufacturers were putting their hands in their pockets in order to find the money with which to pursue technical developments in this field in a practical way.

Cost of Ingot Mould Castings

Commenting on the statement in the Paper that the ingot-mould costs in the plants of the United Steel Companies, Limited, varied in 1934 from 9d. to 1s. 7d. per ton, according to the type of plant and steel being produced, and that the cost of bottoms varied from 1½d. to 4½d. per ton, he said that those figures were very low. The United Steel Companies were engaged largely in making the cheaper classes of steel, whereas the Brown-Firth Company were engaged largely in making special steels, and had found, as pointed out by the authors, that they could not afford to continue using a mould when its internal surface had become in any sense depreciated, because any external defects on the surface of the ingot might be perpetuated in the final material, and that would be a great disadvantage. In view of the care which had to be exercised in that respect, the ingot-mould costs in the Brown-Firth works were from 5s. to 10s. per ton of ingot metal, and the cost of moulds per ton of finished product was substantially higher than those figures. So that this was a very real economic problem. In order to afford a comparison between the figures given in the Paper and those of the Brown-Firth Company, he said that if the company secured 20 casts from a 12-in. by 14-in. mould, the mould cost was 8s. 8d. per ton of ingot; if they secured 200 casts from the mould, the mould cost was reduced to 11d. per ton of ingot. Assuming a yield of from 55 to 60 per cent. of finished product, one could appreciate that when working on the special steels the cost of ingot moulds became a very serious factor indeed; unless the selling price of the finished products was very high, the mould cost was not the 1 per cent. mentioned by Dr. Swinden, but multiples of 1 per cent.

Discussing the use of big moulds, Dr. Hatfield gave figures relating to a mould 12 ft. 3 in. in the chill, 81¼ in. by 77½ in., the weight of ingot produced being 112 tons, the weight of the mould 93 tons, and the cost of the mould £1,600. Such ingots were being made in such moulds regularly and frequently. Assuming that disabilities such as were referred to in the Paper came into operation, and something went wrong with the mould after three ingots were produced, a serious financial loss was sustained. If ten or fifteen ingots were produced, the cost of moulds was still on a plane, as regards cost per unit of steel produced, which called for the most earnest consideration of the Institute and of the mould-makers themselves. He stated publicly that the mould makers were not giving sufficient attention to the subject, they were not helping in a practical way, they were not putting money down for research and they were leaving the steel trade to "carry the baby" all the time. Nevertheless, the latter were able to look after themselves.

Ingots weighing nearly 200 tons were being cast, and it was proposed to cast ingots of much greater weights. What would be the price of a mould to produce an ingot weighing 250 tons? Even these bigger moulds suffered from the disabilities of the smaller moulds, with which the authors had dealt so ably.

Continental Practice

Dr. Hatfield recalled the visit paid by members of the Iron and Steel Institute to Luxembourg last September. They had been entertained magnificently; works were thrown open to them without stint and technical facts were placed before them very freely. In one of the big steelworks there as many as 200 ingots were being produced from one mould; that was in excess of the mould-lives in this country. There were two sides to the question, as the authors had pointed out, but it would hardly be fair to say, without technical support for the statement, that the ingots produced in Luxembourg were worse than ours or that the surfaces were unsatisfactory. But evidence pointed to the fact that the study of ingot moulds on a grand scale, such as Dr. Swinden and himself, with the help of the Heterogeneity Committee, were engaged in, would result in greatly extending the lives of ingot moulds. That would be the reply to the mould makers, who were so much in the wrong in not being present at the meeting to give due welcome and consideration to the magnificent Paper put forward by Dr. Swinden and Mr. Bolsover. If the Institute were so interested in this matter on the technical side, the Ingot Mould Sub-Committee of the Heterogeneity Committee might be persuaded, as time passed, to lay before the Institute the results of their investigations.

Mr. J. G. Pearce (Director, British Cast Iron Research Association) said the Paper was particularly valuable, coming as it did from two authorities having such wide practical experience of ingot moulds. If in some respects the authors had confirmed what was already fairly well understood, such confirmation, in view of their resources and experience, was doubly valuable, because it all added to the data at our disposal in trying to formulate ideas as to why ingot moulds failed and in what directions we must look for improvement. Mr. Pearce said he had felt glad that the authors had put the question of ingot mould costs per ton of steel into better perspective, until he heard the remarks of Dr. Hatfield; and it was astonishing that there was so great a difference in costs when alloy steels had to be dealt with. For ordinary steels it was of no use less exaggerating the savings that were to be effected by making improvements in the mould, and he was glad that the authors had stressed what he regarded as the best reason for improving moulds, the improvement of the surface of the ingot.

Table I was very important and very useful, and, without wishing to impose on the authors' generosity, Mr. Pearce suggested that it would be useful if one or two of those who were specially concerned with ingot moulds could have access to the sketches to which the authors had referred; he did not suggest that the sketches need be printed with the Paper, but he felt that it would be extremely useful to associate the design, size and thickness of the ingots with the lives of the moulds in question.

German Moulds

Mr. Pearce was particularly interested in the references made to German moulds, because he had been in some of the large German ingot mould works, and, judging by their compositions and structures, he had never been convinced that their moulds would give longer lives, if used under English conditions, than we in this country obtained from our moulds. The figures given by the authors in relation to the special German moulds, which were definitely good, related to moulds having finer graphite size and a smaller percentage of phosphorus—two very salient points.

The experience of the authors was that large ingot moulds failed by major cracking; but that experience was not universal. In some works it was found that ingot moulds failed in a manner which would be regarded normally as the ultimate end of an ingot mould, *i.e.*, by crazing on the mould face—the formation of the honeycomb or crocodile marking of small cracks which ultimately joined up and enlarged, so that the mould was discarded because of the markings it made on the surface of the ingots produced. Mr. Pearce agreed that we must look to improvements in design and operation for affording greater resistance to the major cracking; and we must look to changes in composition and structure for greater resistance to minor cracking or crazing.

Co-operation by Ingot Mould Makers

At intervals during the past few years he had had occasion to talk to Dr. Hatfield about what Dr. Hatfield regarded as the indifference to mould improvement of the independent ingot mould maker. Without entering into their reasons, Mr. Pearce believed there was a good deal to be said on their side, and the ingot mould makers could make themselves effective

technically through the British Cast Iron Research Association. He had met them at intervals and had found them quite prepared to supply the material on which investigation could be made; and it was on that basis that some work was done for the Heterogeneity Committee a few years ago.

DR. HATFIELD asked if Mr. Pearce could be precise and could say what the ingot mould makers had done, because he was giving a false impression.

MR. PEARCE replied that, organised through the Research Association, they had played their part in evolving the process to which the authors and Dr. Hatfield had referred.

DR. HATFIELD:—Be honest about it!

MR. PEARCE said that that, at any rate, could be accounted in their favour.

Technical Requirements

It would be premature continued Mr. Pearce, to say a great deal about that particular process at the moment, except that experience and technical examination alike suggested that an ingot mould metal should have a very high carbon content, but that, in order to enable the metal to resist crazing, the graphite should be in a fine state of sub-division. At present it was virtually impossible, under ordinary greensand casting conditions, to produce a high total carbon iron with a very fine graphite. The improvement of cast iron during the last 10 or 15 years by reducing graphite size had been accomplished in the main by reducing the total carbon content; with the reduction of total carbon content, the graphite size was improved. At present, if the iron must have a high total carbon content, one had to risk the graphite being coarse, and the Research Association had made some proposals by which an iron having a carbon content of, say, 3.7 or 3.8 or even 4 per cent. could be produced containing graphite as fine as it was possible to produce graphite in cast iron. Under those conditions he believed the metal was able, by virtue of its carbon content, to withstand the thermal shock imposed by the molten steel, whilst at the same time the fineness of the graphite prevented the entrance, at the working face, of hot gases which led to oxidation, and ultimately to growth and the cracking which he referred to as "crazing."

Higher Phosphorus Suggested

Alternatively, there were various other directions to be explored with regard to composition, one of the most interesting of which was phosphorus. It was not easy to produce an absolutely sound and uniform casting when the phosphorus content was down to hematite value, and that problem had to be explored.

It might conceivably be found that a coarse graphite was ultimately the most desirable form. If that proved to be the case, the B.C.I.R.A. could reverse the process he had mentioned for treating the molten metal, and thus procure an extremely coarse graphite; and if necessary, artificial cavities could be created in the metal. If cavities were helpful, one could produce cavities which did not contain graphite. But there was a limit to that, because a cavity might produce a local hot spot, if a certain limit were exceeded. However, if the cavities could be produced artificially, they might be helpful. Either end could be achieved, and Mr. Pearce welcomed the opportunity of co-operating with Dr. Hatfield's Committee in this direction.

An enormous amount could be done in the direction of ingot mould improvement by effecting improvement in design and in conditions of operation, but it seemed likely that that must be done for each works for its own types of mould and its own particular products. In view of that, there was a good deal to be said for working on what might be called a standard composition, a standard structure, being material which was calculated to give the best results in the ordinary way, leaving it to each works to find out for itself the precise thickness of mould, type of design of mould, lug arrangement and conditions of operation—such as temperature, pouring proximity of moulds to each other, and so on, which factors, as had been shown, had such a pronounced effect on the life of moulds.

Finally, Mr. Pearce commented again on the value of the data provided by the authors, and expressed the hope that Dr. Hatfield would have no reason to complain during the next year or two of the response on the part of the ingot mould manufacturers.

Mould Preparation and Cost Reduction

MR. J. H. COOPER was particularly interested in the Paper because during the last fortnight he had had the opportunity of acting as interpreter for a German who was very much interested in ingot moulds. This German friend, having seen the conditions of casting in this industry, and knowing the conditions in Germany, in the Balkans and in other parts of the Continent, considered that not quite sufficient care was taken here in preparing the moulds before casting. The ingot-mould temperatures when casting in this country were higher than those used on the Continent. He was in a position to be an authority on the subject, because his father was the inventor of the steel mould and had placed it before Messrs. Krupps, at Essen, in 1912 or 1913, receiving from that company a considerable sum by way of licence. He contended that if we in this country exercised care in our treatment of moulds, as was done in Germany, and cast in a proper manner, the lives of moulds in this country would be extended very considerably.

Mr. Cooper did not profess to be the possessor of special knowledge, but having had the opportunity of interpreting for a man who knew his business, who had seen the conditions here and was working on these matters on the Continent, it appeared that the fault might not lie entirely with the ingot-mould makers, but that there might be some fault on the part of the steelmakers. If an extra 2d. or 3d. were spent on the preparation of a mould, it was more than 100 per cent. repaid by the extra life of the mould and the better surface of the ingot produced.

Ascertainment of Cost of Castings

MR. J. BLAKISTON said it was only by collaboration by people such as the authors, who tabulated the facts concerning the lives of ingot moulds in so precise and ideal a manner, that progress could be made to rectify the production of ingot moulds, which gave such uncertain and irregular service.

Commenting on the authors' reference to the Paper he had read before the Middlesbrough Branch of the Institute recently, Mr. Blakiston said that when he had quoted the cost of the castings per ton of semi-finished steel he had been speaking, of course, from the foundry point of view, and he had based his figures on the approximate cost of two separate iron and steel works—one producing a quarter of a million tons and the other producing one million tons per annum. He had not taken into account any credit from scrap returned, but merely the bare foundry cost to the works concerned. He considered that returned scrap might be regarded more or less as a perquisite to the steel plant, in the same way as they regarded basic slag. The figure of 10s. per ton of semi-finished steel, as given in that Middlesbrough Paper, represented the entire cost of all castings used, from the raising of the coal from the colliery to the rolling of the finished product.

With regard to the lives of ingot moulds on the Continent, he said he had received recently a letter from an Austrian iron-producing firm, who had stated that they were supplying their iron to certain firms of ingot-mould manufacturers, and that the latter were securing an average of from 350 to 400 lives per mould. No other details were given as to the characteristics of the iron; but, of course, much depended on the class of steel produced.

Considerable research work had been carried out in connection with the metallurgical treatment with a view to improving the lives of ingot moulds, but research on the method of moulding and the tabulating of results in that direction seemed to have been neglected. He was convinced that the biggest factor determining the lives of ingot moulds was the system adopted for the manufacture of the cores and the subsequent method of cooling and easing of the casting.

Elimination of Core Barrel

He had advocated that, if possible, the core barrel should be eliminated, and he had since learned that a Scottish firm had successfully achieved this, the results they were obtaining from their moulds being much superior to those he had seen in English practice.

There was considerable scope for research in this direction; if a graph were made, plotting the sand strength of the cores against the lives of the moulds, he believed one would find a definite relation. One of the Institute's subcommittees had introduced what was to his mind a very good sand-testing apparatus.

In his opinion, when a mould cracked early in its life, the initial crack or plane weakness was inherent in that mould when it left the foundry. It was useless to say that it was cracked as the result of abuse in the steelworks, because the steelworks' manager was concerned more than anyone in prolonging the life of ingot moulds, and must be credited with that intention. It behoved the foundry, therefore, to produce moulds that would stand up to the requirements of the steel manufacturer.

MR. JOHN SHAW said that the value of the Paper was enhanced by the care which the authors gave to any investigation they undertook. Hence, their data and conclusions should be of great use both to users and makers of ingot moulds. The authors had not attempted to put the onus on anybody, but had given a fair and detailed account of their actual experience.

The figures in Table I were interesting. Without asking for information concerning the abnormal increase in the life of ingot moulds at some works, Mr. Shaw said it would be interesting if the authors could give some more detailed reason for the 30 per cent. difference between the highest and lowest figure at their plant when using the same type of mould made by the same maker. Was it due to a few moulds cracking soon after they were put into service, thus unduly reducing the average life, or was there some other fact to account for it? Whilst there was a fair amount of proof that composition, within the limits usually found in this class of work, was not the dominating factor, the figures given in part of Table II were fantastic and had little meaning.

Where Continental Moulds Excel

Mr. Shaw was in full accord with the authors' remarks concerning the importance of structure. It was generally accepted that a close structure inside the mould was required to resist breaking down, while the background should be open enough to withstand the sudden expansion occurring when the steel was poured in. It was on this matter that Continental makers had a big pull. The iron from the blast furnace was stacked not only by analysis, but in casts; from this it was easy to estimate the ultimate structure. In this country, however, whilst often the analysis was within the limits given, one found structures from a badly-scattered fracture that would melt hard, to open kishy sows that filled the air with flying graphite as the temperature of the molten metal dropped. Yet with a demand for a maximum of 0.05 sulphur and phosphorus, one was almost compelled to use an open iron if cupola melted.

American Practice

Some time ago he had been asked to pick up what information he could regarding the life of

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moulds in the States. The experience at several shops varied a good deal, depending on whether the shop was working on tonnage steels or quality steels. John Kruska, who was an acknowledged authority on the subject, had given data confined to square moulds for from 3- to 5-ton ingots. Briefly, the results were as follow:—

Type of metal.	T.C.	Si.	Mn.	S.	P.	Cr.	Average grade of steel cast in.	Life.
Direct BF. ..	3.80	0.99	1.08	0.035	0.110	—	0.164 per cent. C	69
,, ,, * ..	3.80	0.99	1.08	0.035	0.110	—	0.164 ,, ,,	77
,, ,, ..	4.14	1.31	0.92	0.061	0.106	—	0.12 ,, ,,	62
,, ,, * ..	3.47	1.56	1.23	0.058	0.136	—	0.30 ,, ,,	94
Cupola iron ..	3.66	1.52	1.24	0.051	0.136	—	0.46 ,, ,,	121
,, ,, ..	3.37	1.98	1.18	0.052	0.113	0.78	0.25 per cent. Ni, Cr	119
,, ,, ..	3.27	1.55	0.99	0.079	0.120	0.21	Med. C, alloy steel	138

Whilst these results did not give a definite lead, there were two points to be noted, and which might help. The two items marked * were held in the ladle for 2½ hrs., and in every case tried these castings had given a longer life than those cast at once. Also, the de-sulphurising process as practised by the Valley Mould Company undoubtedly lengthened the life. There was little doubt that the claim made on the Continent, that mould life averaged 150 heats or over, was correct.

Continental Lives

He had visited quite a number of shops. At Trinec the life was given as from 150 to 200 casts. At the same time, there was little doubt that they used a mould for longer than would be tolerated here, as those who had examined a mould shown at the Liège exhibition, which mould had given 230 casts, could testify. This was confirmed by an investigation carried out at Skoda on a mould after use. From a cross-section of this mould, drillings were taken at intervals of ½ in., commencing at a point ¼ in. from the inside surface. The original analysis was T.C. 3.54, Si 1.43, Mn 1.26, and P 0.104 per cent. At ¼ in. from the inside surface the T.C. had dropped to 1.86 per cent., and it was not until a point 1¼ in. from the inside surface was reached that anything like the normal figure was obtained. The Si and Mn were affected in the same way. Mr. Shaw suggested comparison of these figures with those given on page 147 of the Fourth Report of the Committee on Ingot Moulds.

With regard to Table III, he asked if the authors could say where to obtain with regularity iron of Si 1 per cent. and S 0.03 per cent., which would be necessary to give such an analysis from the cupola. Even the analysis of Table III did not guarantee a long life, as was shown by the results with Kruska's direct-blast-furnace metal; it practically came into line, yet it yielded only 69 casts. Mr. Shaw suggested that these moulds were cast from mixer metal, with its purifying and sulphur-reducing action.

Phosphorus Content and Increased Lives

Discussing the effects of increasing various elements, he said claims had been made for phosphorus up to 0.2 per cent., and there was somewhat wide evidence on this point. Some time ago he had been asked to pay special attention to a used mould from Jessop's which had given exceptional life; the only unusual feature discovered was that the phosphorus was up to 0.23 per cent. Further evidence in support of the claim for high phosphorus was furnished by a French Paper, in which reference was made to a mould, cast in error, containing P 0.4 per cent. and which had yielded 214 casts. Phosphorus contents of from 0.15 to 0.20 per cent. were very common.

In Table III the phosphorus contents rose to 0.186 per cent. Whilst it might not be possible to approach this limit, due to re-using, for steel, evidently it was not very harmful to the life of moulds. Mn had also been advocated and had proved beneficial. Groselande had found that by raising the Mn content from 0.6 to 1.75 per cent. the number of casts obtained from one mould had increased from 110 to 175 as an average over two years.

Chrome had also been tried, with a fair amount of success, but much depended on how these additions were made. If they were made in concentrated form, one obtained quite a different structure from that obtained when less drastic means were used.

Treatment in Steelworks

Mr. Ballantine (who represented the Scottish firm referred to by Mr. Blakiston) said that when he examined reports concerning the lives of moulds, he was between the devil and the deep sea. His firm manufactured 6½-ton moulds to a standardised design and supplied them to two different firms, and it was interesting to note that whereas one particular concern obtained something like 150 casts from those 6½-ton moulds, another concern obtained an average of only 50.

Some time ago there had been a discussion as to the effect of low silicon, in conjunction with low manganese, on the life of 20-tonners. He had experienced a very disastrous period with new designs of 20-tonners, and the metallurgists had said that the trouble was due to the silicon being about 1.3 per cent. The manganese never exceeded 0.5 per cent. He was not a metallurgist, but he studied records. Out of 21 moulds made, all 20-tonners, some eight or nine had failed fairly soon. It was reported that the trouble was due to low silicon in conjunction with low manganese. But some 10-tonners were cast in the very same metal, 350 having been made over a period of a year, and there was only one failure. It seemed to him, speaking as a practical foundryman, that the trouble did not arise in the mould foundry itself but in the steelworks.

Machined Tops

Mr. Ballantine asked if the authors had found it advantageous to machine the tops of ingot moulds. He was not aware of the practice in England, but in Scotland the moulds were seldom machined. The steelworks were always looking for a bee in the bonnet, and claimed that moulds ought to be machined at the top. In steelworks one saw moulds from which a piece of dirt had been dug out by means of a pen-knife, and it was said that that was a factor in decreasing the lives of moulds. He had seen billets with as much head on them as there was in the ingot mould itself, and with plenty of dirt. However, it was a delight to listen to this very good discussion on a first-class Paper.

Prof. J. H. Andrew (Professor of Metallurgy, Sheffield University) commented that the Paper dealt largely with the statistical side and contained very interesting data; but one rather missed information which might have been given on the purely metallurgical side. He would be interested to know, for instance, whether the authors had taken depth analyses from a mould which had been in continuous use for a considerable time, to ascertain whether the chemical analysis varied very considerably from the outside to the inside. He also asked if the carbon varied very considerably after use, and whether the authors could give any idea of the variation of microstructure from the outside to the inside after use. Reference was made in the Paper to distortion, and Prof. Andrew asked if the authors regarded this as purely due to expansion or as being due to growth. When one noted the large inter-crystalline cracks in Fig. 9, one was bound to associate the cracking, generally speaking, with large grain size; and, further, the fact that those cracks rather followed the cracks on the skin of the mould suggested that they were due in the first place to oxide penetration. Could the authors give an idea of the nature of the boundary phase after cracking?

Lastly, Prof. Andrew asked why, as pointed out by Dr. Hatfield, the life of a mould used for casting alloy steels should be very much less than that of a mould used for casting ordinary plain carbon steels. He pointed out that most steels of this character were cast at very similar temperatures—the difference was not 50 deg. Did the alloying elements diffuse into the moulds? Why should alloy steels have a more penetrating effect on the mould than had the ordinary carbon steels?

German Ingot Moulds

Dr. P. Longmuir, M.B.E. (Past-President), congratulated the authors upon their excellent Paper, and reminded the audience that Dr. Swinden's first Paper to the Institute, dealing with pyrometry, and presented at Middlesbrough many years ago, was followed by a second, delivered at the second Manchester convention, on cupola slags, which latter remained a classic to-day.

Referring to German ingot moulds, he said that undoubtedly they gave a longer life than the English; but that longer life was not necessarily due to the composition of the metal, and, as a rule, the phosphorus content was higher. Although mixer metal was largely used there, and even direct metal, he believed that the majority of German moulds were cast from cupola metal or, alternatively, from metal melted in furnaces of the Brackelsberg type. Our Continental friends were prone to use lacquers; whether or not that was an advantage it was difficult to say, but Dr. Longmuir said that he had some samples, and if the authors were interested he would be glad to forward them for examination.

Armour Plate Moulds

Mr. J. E. Mercer was particularly interested in the authors' reference to the refinement of the graphite. He recalled that twenty years ago a large firm in Sheffield were engaged in the manufacture of ingot moulds to produce large ingots for armour plates and gun ingots. Difficulties arose through high sulphur content, and short lived moulds. Naturally the foundry were blamed. (The hematite was being melted in cupolas.) It was suggested, and carried out, that the hematite be melted in the Siemens open hearth acid furnace, and on occasion as much as 100 tons would be charged into a furnace. The results were very satisfactory so long as good hematite pig was used—the sulphur content being very low and the refinement of the graphite was considerable; thus giving a much better iron and getting a mass of metal that was homogeneous throughout. In casting the metal into the moulds the iron was put into bottom poured ladles and cast through a stopper. This eliminated the usual mushiness so often prevalent at the top of ingot moulds. Some of these ingot moulds for producing steel ingots up to 60 tons each, gave a life of 120 ingots and had a fairly good surface remaining.

Author's Reply

Dr. Swinden, replying, expressed appreciation, on behalf of Mr. Bolsover and himself, of the fact that the discussion had been so interesting and energetic. He emphasised that the Paper was a joint Paper, noting that Mr. Bolsover was the Convener of the Ingot Moulds Sub-Committee, which was responsible for the collection of the data given in the Paper. As one might

expect, Dr. Hatfield had contributed and was providing data of very considerable value. One looked to him to continue to contribute such data in the future with the generosity he had shown in the past.

Statement of Lives

Commenting on the ingot mould costs given by Dr. Hatfield, Dr. Swinden said he supposed they were the ingot mould costs per ton of finished steel.

Dr. Hatfield replied that that was not so; his ingot mould costs were related to the ingots alone.

Dr. Swinden said that the ingot mould cost of 1s. 7d. per ton, given in the Paper, was the actual figure attained at the Stockbridge branch of his Company for the last two years, and in point of fact, *something like 75 per cent. of the product there was open hearth alloy steel.* He had not given any figures for electric steel in the smaller moulds.

Taking the point raised by Professor Andrew, he said there was no reason, in his opinion, why the lives of moulds used for alloy steel should be shorter than the lives of those used for casting straight carbon steel. In fact, in his experience the most searching metal was dead soft rimming steel and free cutting steel.

Dr. Swinden reiterated the appeal made by Dr. Hatfield for the support of the ingot mould makers, particularly in view of the fact that there had been established, under the Chairmanship of Mr. R. H. Myers, a member of the Institute, a very active joint Committee of the Iron and Steel Institute and the National Federation, the steel-making members of which had, at very considerable trouble, collected (by means of a questionnaire) and presented, very full data; it was hoped that that Committee, in collaboration with Mr. Pearce and the users, would tackle this important matter on a national basis.

Reverting to the ingot mould costs, as given in the Paper, he said they were definitely accurate; there was no question that they represented facts. Whilst the figures quoted by Dr. Hatfield was much higher, it represented, presumably, in the case of alloy steel, a smaller tonnage. But even though the costs might be lower and the potential saving might be lower in one case than in another, the importance of the matter was not lessened, because on a tonnage of 10,000 or 12,000 per week the saving of a few pence per ton represented a very big sum in the aggregate. The Paper constituted a deliberate attempt to assess values and to give some indication of how costs could be reduced.

Further Data Promised

The Paper would have been far too bulky if a section on the metallurgical aspects of the problem had been included, and it would have been bad judgment to have included it. But the authors had a complete report on the metallurgical examination of particular moulds which had failed, and the results of the examination of microstructures and so forth, right through a number of moulds that had failed. If it were so desired, that information might be made the subject of another Paper in the future.

Replying to Mr. Pearce's request that he might be given access to the sketches in connection with the moulds dealt with in Table I, Dr. Swinden said that if at any time Mr. Pearce cared to pay him a visit, he could have copies of the sketches.

Discovering Bad Moulds

It was agreed that some moulds did fail by crazing. But, in the authors' experience, where the average life was low, it meant that a number of moulds had failed after 10, 15 or 20 casts, as against an average of, say, 100, and almost invariably the moulds which had failed prematurely had failed by cracking, and not by sudden and rapid surface deterioration. It sometimes happened that they did get a bad mould! Reference had been made by Mr. Ballantine to the practice of poking about with a penknife; Dr. Swinden said that at his works they made a practice of poking about with a pointed bar, for they had found patches which had been made up with black lead, the result of which was that a mould would fail when it was first used.

One could talk for a long time on the problem as to why moulds cracked, and particularly why a mould cracked at the top corner, which was never in contact with liquid steel. Fig. 2 gave an example of a mould which had cracked from the outside inwards, and that was a very common type of failure.

It was pointed out in the Paper that in the authors' experience the German moulds and others having a somewhat higher phosphorus content than the hematite composition appeared to yield a longer life. The economic aspects, including salvage value, had to be taken into account, but the matter was one upon which attention could with advantage be concentrated in further work.

Care of German Moulds

Commenting on Mr. Cooper's reference to the point that greater care was exercised in the preparation and use of moulds on the Continent than in this country, he said that in the Paper, immediately after Table III, the authors had endeavoured to show that they agreed. They had tried to assess the economic advantage of the German or the English practice, and their experiment—which, incidentally, was duplicated—had shown that there was an advantage of 2.06d. per ton if the particular composition German-type mould referred to were used in accordance with English practice, as compared with the domestic standard mould, and an additional advantage of 1.96d. per ton if the German mould were used in accordance with the German practice. But it must not be forgotten that if that advantage were secured when using the mould for dead soft Bessemer steel, it must not be thought that the same advantage would accrue if one tried to cast high-carbon steel and maintain a decent surface, because it just would not work.

Dealing with the remarks of Mr. Blakiston, he said he now noted that in the figures given in the Middlesbrough Paper no credit was given for returned scrap. Clearly, in estimating the values quoted in the present Paper, the authors had given credit for scrap at the market prices.

He did not know of any work that was in hand concerning the correlation of the sand strength of the cores with mould lives, but no doubt that problem would be noted for further investigation by the national Committee. The problem of the rate of cooling was already on the programme. Moulds were being made under controlled cooling conditions, and the lives of those moulds in service would be noted.

It was a fact, as mentioned by Mr. Shaw and Mr. Ballantine, that there were quite large variations in the lengths of life of what appeared to be similar types of moulds; indeed, were it not so, it would hardly have been necessary to have written the Paper. The authors had tried to show that such variations were due in some cases to shop practice; if one plotted the figures recorded in the Paper, one found that these variations occurred in waves. However, in a consignment of moulds from the same maker, made of material of similar analysis, and used in the same way so far as shop practice could be controlled, quite large variations occurred as between one mould and another; and that result must be laid at the door of the mould maker.

Composition and Mould Life

The author agreed entirely that analysis was not a governing factor; and he drew attention to the statement, in the section of the Paper headed "Influence of Mould Metal on Mould Life," that in their experience, which they believed was in full accord with that of many other observers, the composition could vary within fairly wide limits without any consistent effect on the mould life.

Dealing with Mr. Shaw's request for more data concerning metallurgical examination, he said that decarburisation did occur on the surface and differences of composition did develop a considerable distance back into the mould, with some very weird structures in the intermediate zone, due, no doubt, to penetration of gases.

The moulds referred to in Table III were Werfen moulds; they contained fairly high phosphorus.

A fairly extensive trial now being conducted on moulds made of a material with high manganese content suggested that manganese was beneficial, as Mr. Shaw had mentioned. But the authors did not agree that chromium additions were beneficial; they had obtained certain results on small-scale experiments, but those results were not substantiated in larger-scale experiments, so that they had discontinued the use of chromium.

It was refreshing to hear Mr. Ballantine's remarks, but it would be unwise to attribute the whole of the variations experienced in regard to the behaviour of moulds to bad steelmaking practice. That was not the whole story!

Machined Moulds

As to the practice of machining the top of the mould, Dr. Swinden asked if Mr. Ballantine had meant the top of the mould as cast (which was the bottom of the mould as used) or the top of the mould as used.

Mr. Ballantine said he was referring to machining the top of the mould as cast.

Dr. Swinden replied that it was common practice to machine the bottom of the mould at one of his company's plants, but that was done for a special purpose, because an open-ended mould was used, with a bottom plate having a recessed dish, and it was very important to secure an accurate fit. That practice had led to a very interesting result. The moulds were machined on the bottom in order to register exactly with the bottom plate. But the first ten or twelve moulds used in that way had cracked almost immediately up the side, the obvious reason being that there was no room for the mould itself to expand. When sufficient room was left for expansion, by machining oval holes, the trouble had disappeared. But that was the steelmaker's fault!

Dealing again with the reference to poking about with a pen-knife, he said that when using a mould for uphill casting with a tapered hole in the bottom, often there was soft porous metal around the hole. It was the practice to test that with a sharp bar, because the steel would quickly bite in and pull away a lump, and after two or three heats the mould would be useless. It was important that the mould should be sound in that position.

One did find variations of analysis in a mould, as would be anticipated, and decarburisation on the surface, as well as penetration along the graphite plates.

Distortion

With regard to distortion, Fig. 9 was included in the Paper to show that expansion and contraction and a gradual crazing of the surface occurred, leading ultimately to a type of cracking. But he emphasised that when he had referred to moulds failing prematurely by cracking he did not mean the sort of cracking illustrated in Fig. 9; he had meant cracking which extended right up to the corner and which had no relation to the deterioration of the inside surface.

He and his colleagues would welcome any opportunity of examining further samples of German mould lacquers, which Dr. Longmuir had promised to make available; the more information they could get the more likely would they be able to help themselves and the mould-makers.

(*Concluded on page* 124.)

XUM

Rapid Low-Temperature Fatigue Tests*

APPLICATION TO FERROUS AND NON-FERROUS METALS

By W. D. BOONE and H. B. WISHART

Low-temperature tests on the physical properties of metals have been somewhat neglected in the past—possibly due to little demand for information in this field and also because of the expense of running such tests. Now, with industry developing processes requiring the exposure of metals to sub-zero temperatures, the growth of aviation, and railroads laying and maintaining track in frigid zones, demand for information about the behaviour of metals in this field is increasing.

While most of the low-temperature work on metals has been confined to impact and tension tests, the work presented in this Paper has been confined to a study of the fatigue properties of metals with temperature change. The data give the endurance limits of unnotched and notched specimens of ferrous and non-ferrous metals at various low temperatures as determined by high-speed fatigue machines.

Space in the cold room during these tests was limited and the time of operation of the cold room at each temperature was limited, so the use of high-speed fatigue machines was very desirable. The two machines occupied a floor space only 2 ft. sq., and their speed of operation permitted determination of an endurance limit in about one-quarter the time required with the rotating-beam machines running at 1,800 r.p.m. —a common speed for such machines.

The cold room was 10 ft. sq. by 8 ft. high, enclosed by 12-in. cork walls. A 12-ton Wittenmeier carbon-dioxide compressor system maintained the temperature of the room at any desired values from + 80 deg. Fah. down to − 50 deg. Fah. Other physical-test equipment in the cold room had no appreciable effect upon the operating temperature of the high-speed fatigue machines which were used in this test. The room temperature was regulated to within 3 deg. Fah.

Series-wound electric motors drove the high-speed fatigue machines at 12,000 r.p.m. This type of motor had good operating characteristics for use on a fatigue machine. Under constant load it runs at constant speed, or its speed can be held at any value from 3,000 to 15,000 r.p.m. by a simple adjustment of a rheostat. In the laboratories of the University of Illinois these machines have been operating more than a year with no repairs and little apparent wear.

Fig. 1 shows a diagram of the fatigue machine. Ball bearings A and B of the motor support the rotating element of the machine. Blower C on the motor shaft circulates air to cool the machine. Collet D on the shaft grips the specimen E. Load arm F with a similar collet exerts a bending moment on the specimen E as load cylinder G bears upon load bearing H. When the specimen fails, load arm F drops, tripping cut-off switch J and stopping the machine. The cycles of stress are recorded by counter K driven through a 100 to 1 worm and gear reduction on the rear motor-shaft extension. For low-temperature tests the oil in the bearings was thinned with naphtha as needed. The motors and load bearings operated very satisfactorily at low temperatures.

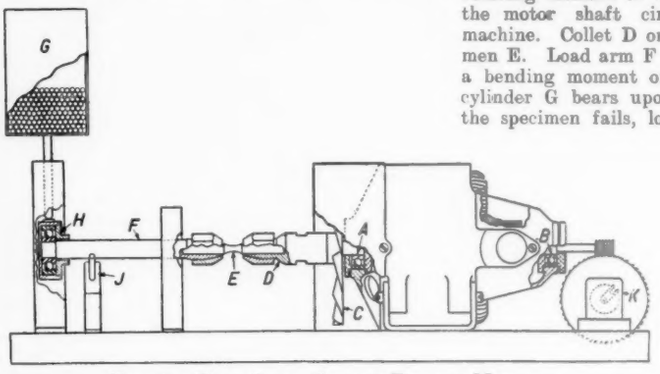


FIG. 1.—HIGH-SPEED FATIGUE-TESTING MACHINE.

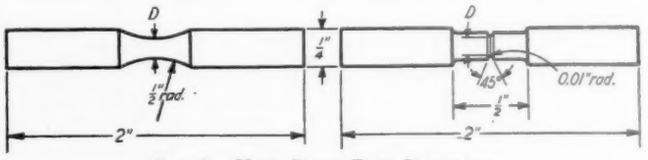


FIG. 2.—HIGH-SPEED TEST SPECIMENS.

The stress in the specimen is computed from the cantilever-beam formula. The distance from the centre line of the load cylinder to the critical section of the specimen, the moment arm of the load, is adjusted to 4.5 in. by a trammel gauge as the specimen is mounted in the machine. The load consists of the weight of the load cylinder G plus a constant for the effective weight of the load arm F at the centre line of the load.

TABLE I.—*Chemical Composition (Per cent.), and Heat-Treatment of Metals Tested.*

Duralumin	3.2 Cu, 95.5 Al, 0.3 Fe, 0.7 Mg, 0.3 Si. (Tested as received.)
Brass (cold drawn)	62 Cu, 35 Zn, 3 Pb. (Annealed 45 min. at 650 deg. Fah., cooled in furnace.)
Gray cast iron	3.25 C, 0.60 Mn, 0.46 P, 0.096 S, 1.1 Si. (Annealed 30 min. at 1,040 deg. Fah., cooled in furnace.)
Meehanite cast iron	3.07 C, 0.9 Mn, 0.15 P, 0.08 S, 1.26 Si. (Tested as received.)
Cold-drawn steel	Tested as received.
Rail steel B	0.72 C, 0.75 Mn, 0.03 P, 0.023 S, 0.15 Si. (Tested as received.)
Rail steel C	0.75 C, 0.76 Mn, 0.024 P, 0.029 S, 0.19 Si. (Tested as received.)

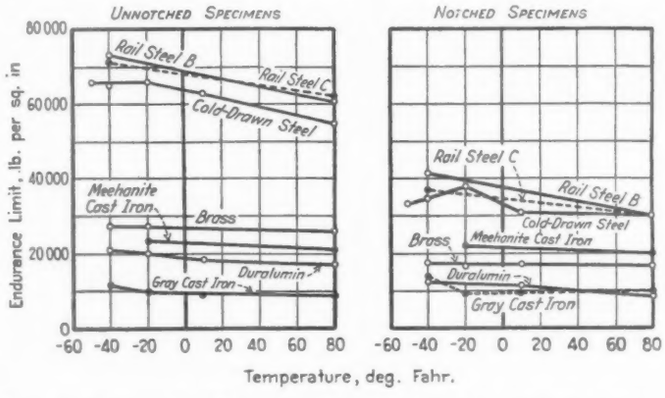


FIG. 3.—VARIATION OF ENDURANCE LIMITS WITH TEMPERATURE CHANGE.

Tests and Test Specimens

Fatigue tests were made on specimens of duralumin, brass, grey cast iron, meehanite, cold-drawn steel and rail steel. Most of the metals were tested at four different temperatures: + 80, + 10, − 20, and − 40 deg. Fah.

TABLE II.—*Endurance Limits and Stress-Concentration Factors at Various Temperatures.*

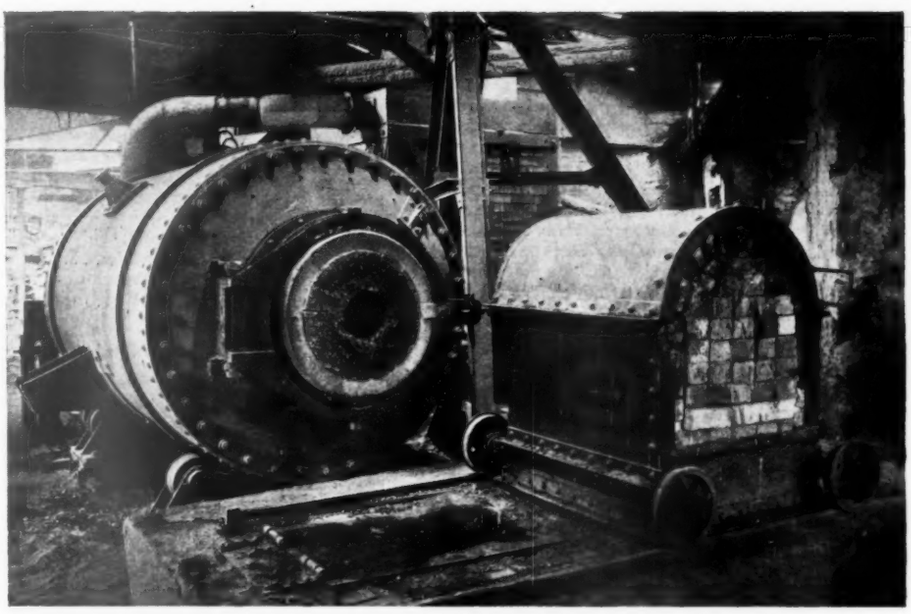
Specimen temp., Deg. Fah.	Duralumin.	Brass.	Grey cast iron.	Meehanite cast iron.	Cold-drawn steel.	Rail steel B.	Rail steel C.
Endurance limit,* lbs. per sq. in.—Unnotched specimens.							
+80	17,000	26,000	9,000	21,000	55,000	61,000	62,000
+10	18,500	—	9,000	—	63,000	—	—
−20	20,500	27,500	9,500	23,000	66,000	—	—
−40	21,000	27,000	11,500	—	65,000	73,000	72,000
−50	—	—	—	—	66,000	—	—
Endurance limit,* lbs. per sq. in.—Notched specimens.							
+80	9,000	17,000	10,000	20,000	30,000	30,000	30,000
+10	12,000	17,500	10,000	—	31,000	—	—
−20	—	16,500	9,500	22,000	38,000	—	—
−40	13,000	17,500	13,500	—	35,000	41,000	37,000
−50	—	—	—	—	33,000	—	—
Stress-concentration factor = Endurance limit unnotched / Endurance limit notched.							
+80	1.89	1.53	0.90	1.05	1.83	2.03	2.06
+10	1.54	—	0.90	—	2.03	—	—
−20	—	1.67	1.00	1.05	1.74	—	—
−40	1.62	1.54	0.85	—	1.86	1.78	1.95
−50	—	—	—	—	2.00	—	—

* Endurance limit based on 50,000,000 cycles for duralumin and brass; other endurance limits based on 10,000,000 cycles.

The cold-drawn steel in addition to these temperatures was tested at − 50 deg. Fah.

Tests of unnotched and notched specimens of each metal were run at each temperature. The test results from the unnotched specimens were

* From a Paper read before the recent Annual Meeting of the American Society for Testing Materials.



STEIN ROTARY MELTING FURNACES.

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THIS 2-ton furnace had already melted 800 tons of Blackheart Malleable Iron when the photograph was taken.

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used as a standard with which to compare test results from the notched specimens, and also to determine the effect of temperature change upon the metal as a whole. The notched specimens were used to study the effect of low temperatures on the effective stress concentration at the bottom of a notch.

Fig. 2 shows the two types of specimens used in the tests. The diameter D at the critical section of the specimens depended upon the material—metals with low endurance limits having large diameters and *vice versa*. The variation of the diameters was necessary in order to keep the load on the specimens within a feasible range. The temperatures of the specimens were measured with a small thermocouple. The specimens ran approximately 5 deg. warmer than the temperature of the cold room. All temperatures mentioned in this Paper are specimen temperatures.

Results

Table I gives the chemical composition and heat-treatment of the metals tested. Table II gives the endurance limits of specimens tested at the various temperatures, and the stress-concentration factors of the notch as determined by the ratio of the endurance limits of the unnotched specimens to those of the notched specimens. For the ferrous metals the endurance limits are based on 10,000,000 cycles of reversed flexure, while the endurance limits for the non-ferrous metals are based on 50,000,000 cycles. Fig. 3 gives a graphical presentation of the data from Table II. In general, the endurance limit of a metal represented by each point on the curve was determined from tests of five or more specimens.

Conclusions

All of the metals tested showed an increase in endurance limit as the temperature was decreased from + 80 to − 50 deg. Fah. The cold-drawn steel, however, after reaching − 20 deg. Fah., showed no further increase in endurance limit.

The stress-concentration factor as determined by the ratio of endurance limits of the unnotched to the notched specimens showed no consistent change with decreasing temperatures. There was enough variation in the stress-concentration factor to indicate that further investigation would be of interest.

The high-speed fatigue machines used in these tests operated satisfactorily at low temperatures. These machines proved to be particularly valuable in shortening the time of the tests, since time was an important factor in the operation of the cold room.

New Motor Cylinder Lubricant

Messrs. Alexander Duckham & Company, Limited, Duckham House, 16 and 18, Cannon Street, London, E.C.4, lubrication technologists, have evolved an entirely new lubricant incorporating a corrosion inhibitor in tablet form, which is soluble in all standard motor fuels. Whilst essentially a wear-preventative medium throughout the life of the engine, these tablets are claimed to have a special value during "running-in." The Institution of Automobile Engineers has confirmed that a reduction in wear of over 34 per cent. with the use of these tablets has been obtained, whilst the largest car manufacturer has reported that wear measured by loss of weight of piston rings, when using the tablets (expressed as a percentage), was 35.9 per cent.

Hebburn Foundry to Start

Messrs. Vickers-Armstrongs, Limited, have completed repairs, reconditioning, and modifications at the Hebburn Foundry, situated in Messrs. Palmer's Hebburn yard, and the foundry is to be put into service at once. Delivery of castings is expected to commence within the next few weeks, and employment will be found for between 60 and 80 men. The foundry will be used primarily for production of castings for the Elswick works.

Stainless Steels

MANGANESE FOR NICKEL

In view of the fact that Germany is compelled to cover the larger proportion of her nickel requirements by imports from abroad, it is not surprising that a considerable amount of research has been, and is being, devoted to the potential replacement of nickel in rustless and corrosion-resisting steels wholly or partially by manganese in order to obtain products with properties comparable to the nickel steels. It is essential, of course, for the element added to produce an austenitic structure as the desirable properties of the nickel steels are largely due to the complete formation of austenite. To determine in how far manganese austenite possesses properties differing from those of nickel austenite, S. S. GÜNZBURG, N. A. ALEXANDROVA and L. S. GELDERMANN carried out a series of investigations which are described in the "Archiv für das Eisenhüttenwesen," and summarised below.

The chrome-manganese steels investigated contained 4.3 to 15.6 per cent. manganese and 17 to 18.5 per cent. chromium; the chrome-nickel-manganese steels, 2.18 to 8.75 per cent. manganese, 2.09 to 6.35 per cent. nickel and 17.20 to 18.20 per cent. chromium; and the chrome-nickel steels 7.85 to 10.22 per cent. nickel and 17.91 to 19.60 per cent. chromium. In 40 melts of rustless steels containing 18 per cent. chromium and 8 per cent. nickel, the nickel was partly replaced by manganese, it being found that nickel promoted austenite formation with roughly double the intensity of manganese, for even when the manganese content had reached 16 per cent. no pure austenitic structure could be obtained. Austenite was formed only after about 2 per cent. chromium had been added to 7 per cent. manganese, or about 6 per cent. was added to 2 per cent. manganese. While the physical and mechanical properties of the manganese steels did not differ much from the chrome-nickel steels, the corrosion resistance of the Cr-Mn and the Cr-Ni-Mn steels was in general lower, although their resistance to attack by nitric acid, sea water and air was found satisfactory.

Production of Highly-Pure High-Melting Metals

At the recent Bunsen meeting of the German chemical societies, PROF. DR. W. KÖSTER of the Kaiser-Wilhelm-Institut für Metallforschung, discussed the importance of physical chemistry to the metallurgical industries, describing *inter alia* a fundamentally new process for producing very pure metals, viz., the decomposition of metallic compounds at high temperatures. This process, the author pointed out was applicable to all classes of metal compound, whether solid, liquid or gaseous, provided decomposition into the metal and a gas takes place below the melting point of the metal. The process has been applied to the preparation of a series of metals, particularly those of high melting point whose compounds usually have a high decomposition temperature. The metal is volatilised in a suitable container and comes in contact with no foreign body likely to contaminate it, so that the product is of a very high degree of purity. One important advantage of the process is that metals such as chromium, vanadium, titanium and zirconium, which are usually brittle and difficult to work when isolated by other means, are obtained in a very plastic and ductile state, indicating that brittleness is due to the impurities in these metals and is not an intrinsic characteristic of the metals themselves.

The process has proved of the greatest value in the manufacture of metallic nickel by the thermal decomposition at a high temperature of the readily-volatile nickel carbonyl. Practically all the nickel now produced is obtained by this means, the product being much purer than that manufactured by the earlier carbon process. The use of metallic carbonyls in fact dispenses with the need for an intermediate fusion stage and alone allows a high degree of purity to be obtained such as is essential for the subsequent manufacture of alloys. The reactions entailed take place in the solid phase, and alloys can be produced by directly sintering compressed materials without passing through a melting stage, the alloys produced being exactly similar to those obtained by fusion processes. Sintering also enables metals to be obtained which cannot be got by melting, because either their temperature of fusion is too high or because the products react with the material of the melting crucible. An important application is to the production of tungsten, molybdenum and tantalum, and the manufacture of super-hard alloy steels for cutting tools.

New Data on Ingot Mould Life

(*Concluded from page* 121.)

As to the suggestion that a higher phosphorus content was not of advantage, Dr. Swinden said he would not go so far as to agree from the point of view purely of mould life; but it was a matter of economics, involving the mould life and salvage value.

Mr. Mercer's interesting remarks confirmed all that Mr. Pearce had said on the importance of treating the mould metal to ensure that the graphite was in the most advantageous form in the resulting mould.

MR. V. C. FAULKNER (Past-President) proposed a very sincere vote of thanks to the authors for having placed such valuable data at the disposal of the Institute and the industry. He imagined that the Paper was one of the most important ever presented at any conference.

The proposal was seconded by the PRESIDENT, and was carried with enthusiasm.

MR. J. G. PEARCE wrote that he heard this Paper delivered at Manchester and was greatly impressed with its value. Few foundrymen have had, or will have, the opportunity of presenting a Paper covering such a range, including as it does iron and steel castings, special alloys and non-ferrous metals in green sand, dry sand and loam and in a wide variety of sizes. It was one of the most practical Papers ever given to the Institute and for many years would be a mine of information for students, teachers of founding and practical men. The illustrations were an important feature. The Paper shows what could be done by a combination of wide practical experience and technical control.

He was naturally especially interested in the comparative results of the heat-resisting irons introduced by the B.C.I.R.A., Silal and Nicrosilal, especially as the comparison iron was what in all probability would be regarded as a good type of heat-resisting iron.

Union Steel Company of South Africa

The board of the Union Steel Corporation (of South Africa), Limited, have increased the capital to £850,000 by creation of 1,200,000 new ordinary shares of 5s. each, and 725,000 of the new shares are being offered at par to preference and ordinary shareholders on the basis of one new for every two shares held. A further 175,000 of the shares are being subscribed at par by the South African Iron & Steel Industrial Corporation and the African & European Investment Company in equal proportions, subject to a commission of 5 per cent. The issue, with the balance to be called up on the "A" and "B" preference shares, will provide sufficient funds for redeeming the Corporation's debenture debt.

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CUMMING FURNACE

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This Week's News in Brief

Trade Talk

THE NORTH EASTERN MARINE ENGINEERING COMPANY, LIMITED, Sunderland, has received the contract for engining two colliers to be built by the Burntisland Shipbuilding Company, Limited, for Messrs. William Cory & Son, Limited.

SOVIET ORDERS FOR British goods and machinery placed in June last included :—Machinery and equipment, £112,451 (£1,040,409 in the period January to June); ferrous alloys and steel, £53,277 (£446,296); and non-ferrous metals, £237,039 (£1,123,606).

MESSRS. J. & A. GARDNER & COMPANY, LIMITED, proprietors of the famous Bonawa Granite Quarries, have placed an order for a 500-ton motor vessel with Messrs. Scott & Sons, Limited, Bowling. This is the first motor vessel to be ordered by the firm; hitherto steamers have been employed to convey the granite from Loch Etive to the south.

MESSRS. HENRY ROBB, LIMITED, Leith, have secured three important contracts within a week, comprising a 14-knot steamer for India, a medium grab-type dredger for Colonial owners, and a Diesel-engined tug for the General Lighterage Company, Limited, for service on the Thames, as well as for pontoons and similar small craft.

MESSRS. SIR WILLIAM ARROL & COMPANY, LIMITED, Glasgow, have received an order for the construction of a "Box" flap dock gate for a new graving dock to be built at the port of Halsingborg, Sweden. The placing of this order follows an extensive examination by the Swedish authority of various types of gates and caissons supplied by Continental and British contractors.

A NEW ALLOY, called "Pistonel," has recently been evolved. It is stated to be twice as strong as ordinary aluminium, and exhibits properties which the inventor claims render it far superior to the alloys at present being used in piston manufacture. This alloy has been developed by Mr. J. H. Ballantyne, B.Sc., of "Redcliffe," 104, Ormonde Avenue, Muirend, Glasgow, S.4.

MESSRS. HURST NELSON & COMPANY, LIMITED, have secured 40 orders for 12-ton coal-carrying wagons from a large Fife company and 160 from a Yorkshire colliery. The orders are believed to be an index of improved conditions in the coal-getting and carrying trade. The present position and future prospects of the Lanarkshire rolling-stock industry are said to be better than for many years.

DURING THE last seven or eight weeks no fewer than 26 jaw crushers and jaw granulators have been ordered, and are at the moment passing through the shops of Edgar Allen & Company, Limited, Imperial Steel Works, Sheffield. Considering that these machines represent only one small section of the machinery manufactured by this department, which includes tube mills, ball mills, cement-making plant, lime hydrators, rotary kilns, rotary dryers, etc., it is an interesting testimony to the improved conditions obtaining in the British foundry industry.

STERLING MANUFACTURING COMPANY, Cubitt Town, London, E.14, are again extending their enamelling plant, and have ordered a large Equi-Radiant gas-fired muffle from the Incandescent Heat Company (bringing the total to four large muffles and one small). They are also installing another high pressure blast cleaning table, and have added further grinding mills to the milling department. The builders have just completed a new pressing shop, and the firm is now equipped for many kinds of pressings, such as geyser cases, and table tops, etc.

THE DEPARTMENT OF OVERSEAS TRADE announce that they have appointed the London Press Exchange, 110, St. Martin's Lane, W.C.2, to be their advertising agent for the British Industries Fair of 1936, which will be held in London and Birmingham from February 17 to 28. This appointment has been made in accordance with existing arrangements whereby the advertising agent of the Fair is changed periodically. Mr. Sydney Walton will again direct the news services for both London and Birmingham, and news will be handled by Mr. Robert Williamson, from 10, Adam Street, Adelphi, W.C.2.

PRELIMINARY STEPS in the formation of an association embracing scrap iron and steel merchants in London and the South of England were taken at a recent meeting in London. It was decided to name the association "The London and Southern England Scrap Iron and Steel Merchants' Association," and to become affiliated to the National Federation of Scrap Iron and Steel Merchants. Mr. Lawrence Levy (George Cohen, Sons & Company, Limited) is to be the first President, Mr. H. G. Faull (Thos. W. Ward, Limited) Vice-President, and Mr. Felix Levy (George Cohen, Sons & Company) hon. secretary and treasurer.

FULL-TIME WORKING has been resumed during the past week in practically all departments of the North British Locomotive Company's works in Springburn, Glasgow. The works have been on five days per week since the beginning of the year. The firm has a large amount of work on hand, comprising 20 locomotives for the L.N.E.R., 50 locomotives for the Egyptian States Railways and two locomotives for the Newfoundland Government Railway. Further orders have recently been secured, including duplicate locomotive boilers for the Canton Hankow Railway and the Peiping Hankow Railway, and duplicate conversion parts for locomotive boilers and cylinders for the Nizam's State Railway.

MR. ALAN E. L. CHORLTON, M.P., visited the works of Messrs. Mather & Platt, Limited, Manchester, on July 31, on the occasion of the annual distribution of prizes at the works day-continuation school. The teaching at this school—carried on during working hours—is non-vocational in character throughout the early years of a boy's apprenticeship, and only assumes a technical nature after the boys have gained practical experience in the works and have approached the stage of definite technical education or examination for an engineering degree. There is little doubt that the experiment has been successful since its inception some years ago, and a high standard of results has been obtained in various external examinations.

THE PATENT GEAR & METAL HARDENING COMPANY, LIMITED, of 69, Horseferry Road, Westminster, London, S.W.1, has now changed its name to Shorter Process Company, Limited, and is moving its head office and main works to Celtic Works, Savile Street, East, Sheffield, 4. The company has for a number of years carried on a large business in the hardening of gears and other metal parts, under the "Shorter" patents, and is now engaged in installing some of the latest types of hardening machines in the new works at Sheffield. The "Shorter" process is well known amongst manufacturers and users of gears in particular, and it is hoped that, with more commodious premises and improved facilities, the company will be able to offer increasing service in a process that has been proved and given satisfaction in a large number of industries.

Contracts Open

Pretoria, August 30.—3,334 cast-iron spigot and socket pipes, 3½ in. by 9 ft., and 100 bonding clips, for the Union Tender and Supplies Board. The Department of Overseas Trade. (Reference T.Y. 5140.)

Buenos Aires, August 27.—Seventeen electric pumping sets for deep-well service, for the Argentine National Sanitation Works Department. The Department of Overseas Trade. (Reference T.Y. 5126.)

Doveridge, August 19.—250 yds. of 3-in. dia. cast-iron socket and spigot water mains, for the Ashbourne Rural District Council. Mr. H. Litchfield, Compton Offices, Ashbourne. (Fee £1 1s., returnable.)

Johannesburg, September 9.—Twelve 4-ton electrically-driven portal jib cranes and spares for the Table Bay Docks, for the South African Railways and Harbours Administration. The Department of Overseas Trade. (Reference T.Y. 5116.)

Deanshanger, August 19.—Small pumping station, 1,400 yds. of 4-in., 3-in. and 2-in. cast-iron mains, and other works and material, for the Towcester Rural District Council. Mr. A. J. Dent Young, Trafalgar Place, Combe Down, Bath. (Fee £2 2s., returnable.)

Cairo, September 5.—Power-station plant and equipment, including Diesel engines, alternators, switchgear, pumping sets, workshop machine tools, storage reservoirs, one overhead travelling crane, etc., for the Ministry of the Interior. The Department of Overseas Trade. (Reference T.Y. 10028.)

Personal

MR. V. E. MINICH, managing director of the American Foundry Equipment Company, of Mishawa, Ind., is in London on a business trip, and is staying at the Cumberland Hotel.

MR. JOHN PATERSON, of Riccarton, near Kilmarnock, has been presented with a gold watch on the occasion of his retirement after 38 years' service with Messrs. Glenfield & Kennedy, Limited.

MR. D. CAMERON, formerly superintendent of Messrs. Singer's Clydebank factory, has been appointed general manager of the firm, and is at present organising the new factory at Monza, Italy.

MR. J. MURDOCH, secretary of the Singer Company, Limited, Clydebank, has been appointed managing director of the firm, in succession to Mr. W. J. Rickey, who died recently. Mr. Murdoch joined the Singer Company in 1881, and has been secretary for over 25 years.

Obituary

MR. WARWICK BROOKES, formerly a director of Messrs. Booth & Brookes, Limited, ironfounders and makers of pianoforte frames, of Burnham-on-Crouch, Essex, and a well-known figure in the business and amusements catering world, died last week.

MR. H. BODEN, who was formerly works manager of the Motherwell Iron & Steel Works, died recently. He was for many years employed in the old Globe Malleable Works, before going to Motherwell Iron & Steel Company. Mr. Boden was in his 71st year, and is survived by Mrs. Boden and a grown-up family.

MR. WILLIAM CARNEGIE, a former Sheffield steelworks manager, has died at his home in London. He joined the Sheffield staff of Messrs. Cammell Laird & Company, Limited, in October, 1914, going from Woolwich to manage the shell department during the war period. In 1918 he was made manager of the firm's Grimesthorpe works, and retired in May, 1927.

Company Reports

International Nickel Company of Canada, Limited.—Dividend of 20 cents per share on the common stock.

Broken Hill Proprietary Company, Limited.—A cable from Melbourne states that the net profit for the year ended May 31 last was £670,442, after providing £541,949 for depreciation and £26,241 for debenture interest.

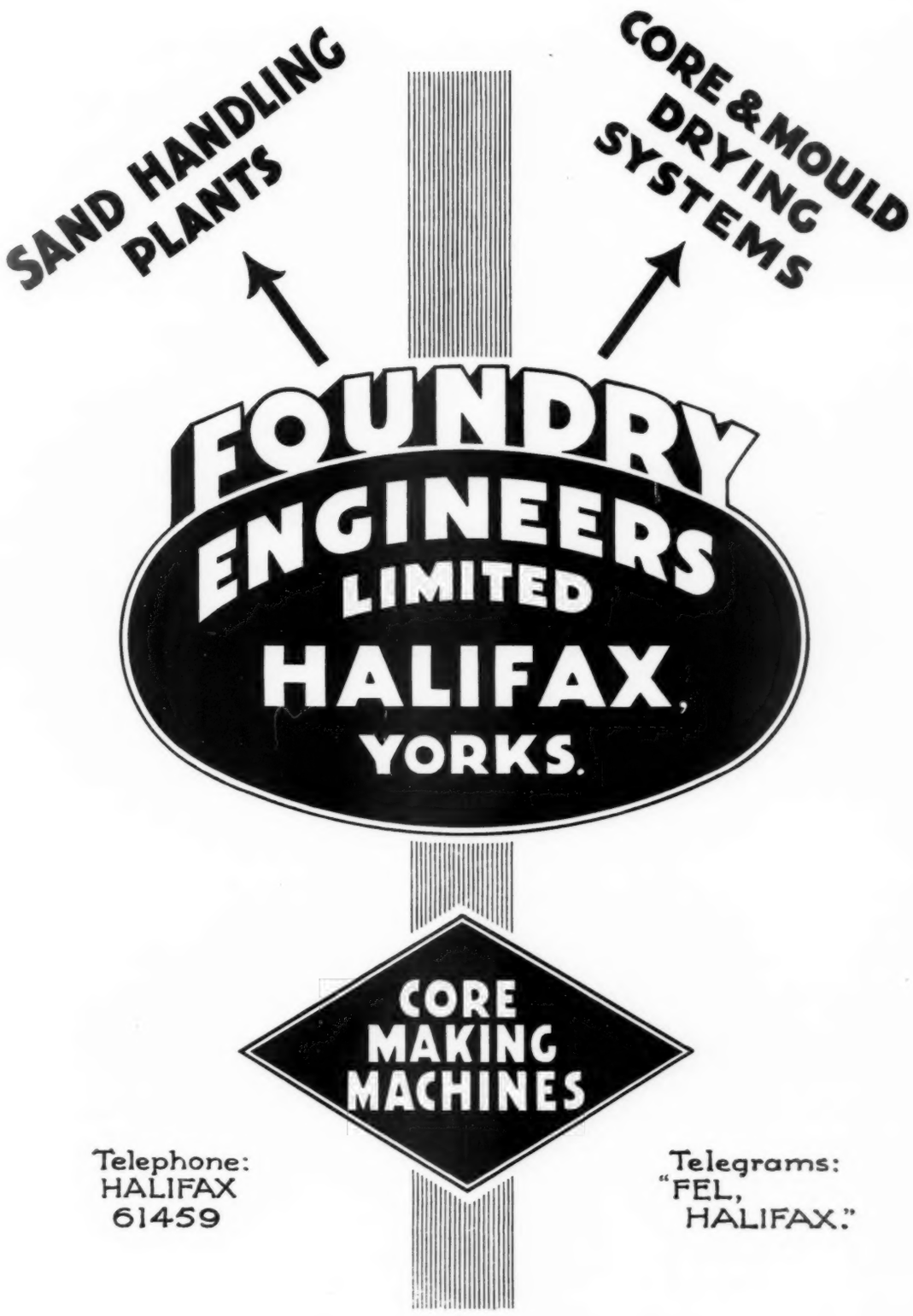
Frederick Braby & Company, Limited.—Profit, £50,901; brought in, £2,529; depreciation, £11,854; interim on preference and employees' shares, £5,235; final dividend on preference and employees' shares, £5,235; dividend of 7 per cent. on ordinary shares, £21,429; carried forward, £9,677.

Bengal Iron Company, Limited.—Profit for year to March 31, £66,202; depreciation, £37,058; debenture interest, £60,721; written off debenture discount account, £1,000; payable to trustees for the debenture holders, £521; debit balance, £33,098; debit brought in, £215,512; carried forward at debit of profit and loss, £248,610. In March last, owing to the increased demand for pig-iron, it was decided to restart No. 5 furnace and this has been working satisfactorily. In connection with the starting up of the furnace, the Indian Iron & Steel Company, Limited, intimated in March last that they intend to make a claim against the company for breach of agreement. Meeting August 14.

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

T. & T. Assets, Limited.—Capital £335,000. To acquire any part or parts of the undertaking, properties, assets, rights and powers of the Armstrong Whitworth Securities Company, Limited. Directors: Major-Gen. Guy P. Dawnay, Sir Edward J. Reid, Edwin B. Lockhart, Chas. B. Gardner and E. H. D. Skinner. Solicitors: Allen & Overy, 3, Finch Lane, London, E.C.3.


SAND HANDLING PLANTS
CORE & MOULD DRYING SYSTEMS
FOUNDRY ENGINEERS LIMITED
HALIFAX, YORKS.
CORE MAKING MACHINES
Telephone: HALIFAX 61459
Telegrams: "FEL, HALIFAX."

Raw Material Markets

Both steelmakers and pig-iron producers are in the happy position of being more favourably placed during this holiday period than for many years past. An additional factor in the prospects of the home works is the agreement with the Continental Steel Cartel, which ensures that imports will be maintained at a reasonable level and that home producers will share in any export trade benefit that may arise. Owing to the large demand for pig-iron it is likely that output will be increased. It is not now expected that any change in the prices of common irons will take place, at least for the time being.

Pig-Iron

MIDDLESBROUGH.—Pig-iron producers are very favourably placed, but up to the present the expansion in the output of pig-iron has been of a smaller volume than in the production of steel. Expectant of a rise in prices, consumers have placed orders for quantities beyond their known requirements and producers have sold the majority of their output to the end of the year. The quotation for No. 3 Cleveland G.M.B. is 67s. 6d. per ton, and for No. 1 foundry 70s., with No. 4 foundry and No. 4 forge at 66s. 6d. Delivered prices of No. 3 G.M.B. in other districts are:—North-East Coast 69s. 6d., Falkirk 67s. 3d. and Glasgow 70s. 3d. per ton.

Most of the available output of hematite over the next six months had been purchased before the prices were advanced, and buyers are not hesitating now to pay the increase. The new schedules are still not quite completed, but the basic figure for No. 1 quality in all districts of production is 71s. per ton and the other chief prices for East-Coast hematite are 72s. delivered Tyneside, 73s. 6d. delivered Durham and Northumberland, 77s. 6d. delivered Scotland, 78s. 6d. delivered Sheffield, and 84s. 6d. delivered Birmingham. A resumption in the Italian export trade is expected to materialise in the near future, when the uncertainty regarding the operation of the new Government monopoly is cleared.

LANCASHIRE.—Forward buying has decreased after the recent spell of contract buying, and as most consumers are well covered for some time ahead, an advance in price would not seriously affect this area. Pig-iron deliveries have been less this week owing to holiday interruptions, but a resumption is expected shortly. For delivery to consumers in the Lancashire price zone, offers of Staffordshire, Derbyshire and Lancashire brands of No. 3 foundry iron equal to Derbyshire are all on the basis of 74s. per ton, with Northamptonshire at 72s. 6d., Scottish foundry at around 81s. 6d., and West Coast hematite at 81s.

MIDLANDS.—Very little new business has occurred in this district since the Central Pig-iron Producers' Association decided not to change the old outstanding level of prices. Most of the users are well covered, and consequently new transactions are likely to be scarce for some months. The minimum quotations delivered Birmingham and Black Country stations, subject to rebate to large users, are 67s. 6d. for Northants No. 3 and 71s. for Derbyshire, Lincolnshire and North Staffordshire No. 3. General engineers and jobbing ironfounders are taking up fairly large quantities of pig-iron, but on the whole business is slow and is likely to remain so until after the holiday period. Low-phosphorus iron including Scottish No. 3, is at from 85s. to 90s., with medium-phosphorus from 72s. to 80s. For specially refined iron the prices range from £5 7s. 6d. to £7 delivered this district. Hematite prices are now fixed at:—West Coast mixed numbers, foundry grades, 84s. 6d., with East Coast No. 1 at the same figure, and 6d. less for No. 3. Welsh makers quote mixed numbers at 83s.

SCOTLAND.—A steady demand for pig-iron is reported from this area, hematite and basic being especially called for. The light-castings trade is taking up a good volume of pig-iron, but the position of the heavy-castings foundries is not good owing to the very quiet conditions in the shipbuilding trade. Scotland received 3,186 tons of Cleveland iron last month in addition to local iron. The official minimum of 70s. f.o.t. furnaces for Scottish No. 3 is unchanged, and No. 1 is 2s. 6d. extra. No. 3 Cleveland iron remains at 67s. 3d. f.o.t. Falkirk and 70s. 3d. f.o.t. Glasgow, with other English foundry iron at 1s. 3d. per ton less. Good deliveries of pig-iron are being made to the steelworks, where great activity is reported. Prices of steel-making irons are unchanged at 71s. for mixed numbers West Coast hematite, 77s. 6d. for ordinary mixed numbers East Coast hematite, and 70s. (less 5s. rebate) for British and Indian basic, all delivered steelworks in this area.

Coke

Prices in this market are stationary and very little activity is reported. Consumers are not covering for their future needs as yet. Durham foundry coke is at 20s. to 21s. at ovens. For delivery in Birmingham and district best Durham coke is offered at between 34s. and 40s., Welsh from 31s. up to 42s. 6d. and Scottish low-ash coke is at 39s. to 40s. per ton.

Steel

The steel markets have entered the quietest trading period of the year; but so far the demand has been well maintained, says the official report of the London Iron and Steel Exchange, probably as a result of the firm tendency of prices. In the semi-finished steel department business has been active, and apparently the sale of Continental material has been on a limited scale. Most of the British producing works are well supplied with orders and are likely to be busy for some months to come. Heavy deliveries are taking place to consuming works, but the demand shows no signs of slackening. Practically all departments of the finished steel market are well employed. Most of the business transacted is on home account, but lately export trading has been more active. Apparently most of the Continental steel quota for the next three months has been sold; but this has had no influence upon the demand for British steel material.

Scrap

Scrap prices in the Cleveland area are still unchanged, although there are possibilities of a rise. The American quotation for steel scrap has again advanced 50 cents per ton. Home supplies will now be subjected to greater pressure. A heavy demand for melting scrap at 52s. 6d. per ton is being met. Foundry cast iron is at 52s. 6d. and 55s. has been paid for good machinery metal in handy sizes. Light metal is at from 43s. to 43s. 6d. per ton, and turnings and borings are at 37s. 6d. and 27s. 6d. per ton respectively, delivered consumers' works. The South Wales market is quiet. Business is weak, consumers being well covered for some time to come. Heavy mild-steel scrap in furnace sizes is at 55s. to 56s. and bundled steel scrap is in moderate call at 52s. to 54s. Small parcels of good, clean, heavy, mild-steel turnings have changed hands at 45s. to 46s. Good cast-iron machinery scrap for foundry uses has a limited local demand at 52s. 6d. to 55s. Reports from the Midland market put heavy steel in furnace sizes at 44s. to 45s., and mixed heavy iron and steel scrap at 42s. 6d. to 43s. 6d. Steel turnings are at 34s. The prices of cast-iron scrap are unchanged. In the Scottish market the consumption of scrap has considerably improved. Prices are firm, but remain unchanged. Consumption is good at steelworks, ironworks and foundries.

Metals

Copper.—New business in this market has been rather slow owing to holiday interruptions, but, on the whole, the general undertone has been firm. Favourable reports from the United States have given increased confidence in this country. A good demand for copper has been experienced in the United States and the total bookings for July amounted to 73,500 tons. The current price of copper in this country is by no means excessive, and producers are hoping that it will rise slowly in preference to making a quick upward move. A slow rise in price would be much less likely to have unwanted repercussions and so unsettle the market. A hopeful view is taken of the outlook for the remainder of the year in nearly all quarters.

Daily market prices :—

Cash.—Thursday, £32 3s. 9d. to £32 5s.; Friday, £31 17s. 6d. to £31 18s. 9d.; Monday, £32 to £32 1s. 3d.; Tuesday, £31 18s. 9d. to £32; Wednesday, £31 17s. 6d. to £31 18s. 9d.

Three Months.—Thursday, £32 11s. 3d. to £32 12s. 6d.; Friday, £32 5s. to £32 6s. 3d.; Monday, £32 7s. 6d. to £32 8s. 9d.; Tuesday, £32 6s. 3d. to £32 7s. 6d.; Wednesday, £32 5s. to £32 6s. 3d.

Tin.—The increase of 15 per cent. in quotas, which was announced after a meeting of the International Tin Committee, now brings the total increase during the current quarter to 20 per cent. Consumption generally is well maintained. An irregular tone prevails on the market as a result of the quota increase, and the future may be regarded as indefinite. Since the announcement of the new quotas was made a severe decline in prices has been registered, and so far the market has recovered none of the lost ground.

Day-to-day fluctuations :—

Cash.—Thursday, £233 15s. to £234; Friday, £228 to £231; Monday, £223 10s. to £224; Tuesday, £219 to £219 10s.; Wednesday, £211 to £213.

Three Months.—Thursday, £216 5s. to £216 10s.; Friday, £212 to £212 10s.; Monday, £209 15s. to £210 5s.; Tuesday, £209 5s. to £209 10s.; Wednesday, £208 10s. to £208 15s.

Spelter.—Consumption has on the whole been fairly well maintained, and the general opinion is that unless a drop in consumption occurs the price of spelter should tend to increase. At the moment, a diminution in consumption seems very unlikely. The United States market is still quiet, but steady. The July figures for the United States are disappointing. The production has increased a little and shipments, although higher than those for June, are not high enough to balance the output. As a result stocks have increased by about 3,000 tons.

Official quotations were as follow :—

Ordinary.—Thursday, £14 7s. 6d.; Friday, £14 6s. 3d.; Monday, £14 6s. 3d.; Tuesday, £14 6s. 3d.; Wednesday, £14 6s. 3d.

Lead.—This metal continues to be steady and the consumption is well maintained. Satisfactory conditions are reported from the United States and from the Continent. The price of lead in America has advanced, and reports state that the Eagle-Picher Company, of Galena, Kan., have restarted their lead smelter on full time. This smelter was closed for two months as a result of a mining strike.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 12s. 6d.; Friday, £15 10s.; Monday, £15 12s. 6d.; Tuesday, £15 12s. 6d.; Wednesday, £15 15s.

53, Victoria Street, Westminster, London, S.W.1.
ACID RESISTING LACQUERS
J. N. CLIFTON
FERRO ALLOYS
Silico Manganese, etc.
Ferro Silicon.
Telegrams: Newclift, Sowest, London.
Telephone: Victoria 1852.
DIAMITE WHEEL DRESSING TOOL
(Agent for London and District).

XUM

Sterling

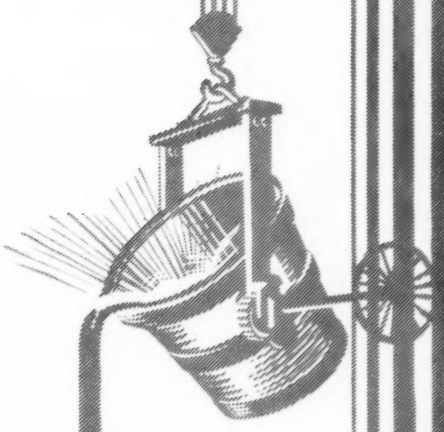
MOULDING BOXES

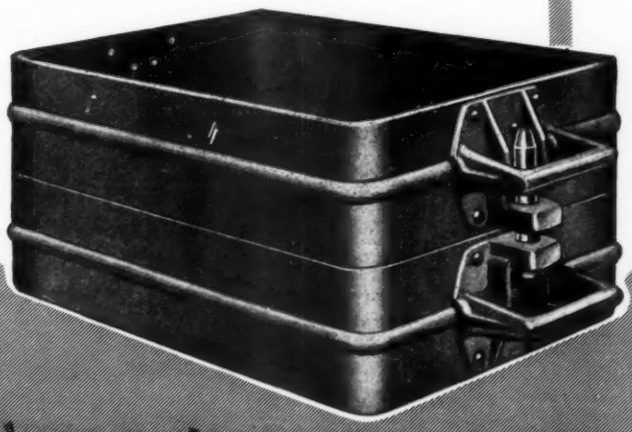
... are designed for the modern foundry

One of the greatest improvements you can introduce into your foundry is the STERLING ROLLED STEEL MOULDING BOX . . . the result is speed and economy all round. Your moulders will put down more moulds per day because of the light and easy handling properties of these boxes.

You will be sure of producing accurate castings because STERLING BOXES maintain their accuracy permanently.

Sterling Boxes—Save their cost in a few months, and are obviously a sound investment for any foundry.





SPECIFY "STERLING" BOXES WITH YOUR NEXT ORDER

STERLING FOUNDRY SPECIALTIES LTD.

STERLING WORKS **BEDFORD**

LONDON OFFICE: 13 VICTORIA STREET, WESTMINSTER, S.W.1.

RAW MATERIALS—PRICE LIST

(Wednesday, August 14, 1935)

COPPER

	£ s. d.
Standard cash	31 17 6
Three months	32 5 0
Electrolytic	35 7 6
Tough	33 10 0
Best selected	34 0 0
Sheets	62 0 0
India	45 0 0
Wire bars	35 15 0
Ingot bars	35 15 0
H.C. wire rods	39 5 0
Off. av. cash, July	31 1 4 11/16
Do., 3 mths., July	31 9 7 5/16
Do., Sttlmnt., July	31 1 7 1/8
Do., Electro, July	34 11 10 5/8
Do., B.S., July	33 16 11 1/3
Do., wire bars, July	34 18 5 17/32
Solid drawn tubes	10d.
Brazed tubes	10d.
Wire	6d.

BRASS

Solid drawn tubes	9½d.
Brazed tubes	11½d.
Rods, drawn	8d.
Rods, extd. or rlld.	4½d.
Sheets to 10 w.g.	7½d.
Wire	7⅜d.
Rolled metal	7d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5⅞d.
Do. 4 × 3 Sheets	5¾d.

TIN

	£ s. d.
Standard cash	211 0 0
Three months	208 10 0
English	211 10 0
Bars	212 10 0
Straits (nom.)	215 0 0
Australian (nom.)	211 10 0
Eastern	210 2 6
Banca (nom.)	213 0 0
Off. av. cash, July	232 12 7 3/32
Do., 3 mths., July	233 8 8 2/32
Do., Sttlmt., July	232 14 4 1/32

SPELTER

	£ s. d.
Ordinary	14 6 3
Remelted	14 17 6
Hard	11 15 0
Electro 99.9	16 18 9
English	15 7 6
India	13 0 0
Zinc dust	19 0 0
Zinc ashes	3 5 0
Off. aver., July	14 2 6
Aver. spot, July	14 1 3 1/32

LEAD

	£ s. d.
Soft foreign ppt.	15 15 0
Empire (nom.)	16 15 0
English	17 15 0
Off. average, July	14 9 7 13/32
Average spot, July	14 9 0 8/32

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	22 12 6
Do., V.M. ex-whse.	24 0 0
Rods	29 0 0

ANTIMONY

	£ s. d.
English	74 0 0 to 75 0 0
Chinese, ex-whse.	69 0 0
Crude, c.i.f.	28 10 0

QUICKSILVER

Quicksilver	11 2 6 to 11 12 6

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	12 15 0
75%	17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£16 0 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	33 10 0
4/6% car.	21 15 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome—	
Max. 2% car.	34 0 0
Max. 1% car.	36 5 0
Max. 0.70% car.	37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/6 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to 11 5 0
76/80% packed	£11 15 0 to 12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 5/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

South Wales—	£ s. d.	£ s. d.
Heavy steel	2 15 0	to 2 16 0
Bundled shrngs.	2 7 6	to 2 15 0
Mixed iron and steel	2 10 0	to 2 11 0
Heavy cast iron	2 10 0	to 2 12 0
Good machinery	2 12 6	to 2 15 0

Cleveland—	
Heavy steel	2 12 6
Steel turnings	1 17 6
Cast-iron borings	1 7 6
Heavy cast iron	2 12 6
Heavy machinery	2 14 0 to 2 15 0

Midlands—	
Light cast-iron scrap	2 7 6
Heavy wrought iron	2 17 6
Steel turnings	1 14 0

Scotland—	
Heavy steel	2 10 0
Ordinary cast iron	2 11 6
Engineers' turnings	2 0 0
Cast-iron borings	1 17 0 to 1 18 0
Wrot-iron piling	2 17 6
Heavy machinery	2 16 0

London—Merchants' buying prices, delivered yard.

Copper (clean)	27 0 0
Brass	18 0 0
Lead (less usual draft)	13 10 0
Tea lead	10 0 0
Zinc	9 0 0
New aluminium cuttings	66 0 0
Braziery copper	23 0 0
Gunmetal	25 0 0
Hollow pewter	160 0 0
Shaped black pewter	120 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
,, at Falkirk	67/3
,, at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	71/-
Hematite M/Nos.	70/6

N.W. Coast—	
Hem. M/Nos. d/d Glas.	75/-
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-

Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
,, No. 3 fdry.	71/-
Northants forge	63/6
,, fdry. No. 3	67/6
,, fdry. No. 1	70/6
Derbyshire forge	67/-
,, fdry. No. 3	71/-
,, fdry. No. 1	74/-

Scotland—	
Foundry No. 1, f.o.t.	72/6
,, No. 3, f.o.t.	70/-
Hem. M/Nos. d/d	71/-

Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	68/6
Lincs forge	64/6
,, fdry. No. 3	68/6
W.C. hematite	86/-

Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	81/6
Clyde, No. 3	81/6
Monkland, No. 3	81/6
Summerlee, No. 3	81/6
Eglinton, No. 3	81/6
Gartsherrie, No. 3	81/6
Shotts, No. 3	81/6

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	9 12 6	to 9 15 0
Nut and bolt iron	7 10 0	to 8 0 0
Hoops	10 10 0	and up.
Marked bars (Staffs) f.o.t.	12 0 0	
Gas strip	10 10 0	and up.
Bolts and nuts, ¾ in. × 4 in.	14 2 6	and up.

Steel—	£ s. d.	£ s. d.
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.	9 5 0	to 9 7 6
Chequer plts.	10 7 6	
Angles	8 7 6	
Tees	9 7 6	
Joists	8 15 0	
Rounds and squares, 3 in. to 5½ in.	9 7 6	
Rounds under 3 in. to ⅜ in. (Untested)	8 12 0	
Flats—8 in. wide and over	8 12 6	
,, under 8 in. and over 5 in.	8 17 6	
Rails, heavy	8 5 0	to 8 10 0
Fishplates	12 5 0	to 12 10 0
Hoops (Staffs)	9 7 0	
Black sheets, 24g. (4-t. lots)	11 0 0	
Galv. cor. shts. (,,)	13 0 0	
Galv. flat shts. (,,)	13 10 0	
Galv. fencing wire, 8g. plain	14 10 0	
Billets, soft	5 10 0	and up.
Billets, hard	6 17 6	to 7 2 6
Sheet bars	5 5 0	to 5 10 0
Tin bars	5 5 0	to 5 10 0

PHOSPHOR BRONZE

	Per lb. basis.
Strip	9¾d.
Sheet to 10 w.g.	11½d.
Wire	12d.
Rods	11d.
Tubes	13½d.
Castings	12d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.31
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Malleable, Valley	18.50
Grey forge, Valley	18.00
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37½
Billets	27.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	19/- to 20/-
Durham foundry	20/- to 21/-
,, furnace	16/6 to 17/9
Scotland, foundry	28/-
,, furnace	25/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/2 and up.
,,	28×20 ,,	36/4 and up.
,,	20×10 ,,	26/- to 26/3
,,	18¾×14 ,,	18/9 to 19/-
C.W.	20×14 ,,	15/6
,,	28×20 ,,	32/6
,,	20×10 ,,	22/9
,,	18¾×14 ,,	15/6

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£30 0 0 to £31 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.		
Aug. 8 ..	32	3	9	dec.	2/6
„ 9 ..	31	17	6	„	6/3
„ 12 ..	32	0	0	inc.	2/6
„ 13 ..	31	18	9	dec.	1/3
„ 14 ..	31	17	6	„	1/3

Electrolytic Copper

	£	s.	d.		
Aug. 8 ..	35	10	0	No	change
„ 9 ..	35	7	6	dec.	2/6
„ 12 ..	35	5	0	„	2/6
„ 13 ..	35	5	0	No	change
„ 14 ..	35	7	6	inc.	2/6

Standard Tin (cash)

	£	s.	d.		
Aug. 8 ..	233	15	0	No	change
„ 9 ..	228	0	0	dec.	115/-
„ 12 ..	223	10	0	„	90/-
„ 13 ..	219	0	0	„	90/-
„ 14 ..	211	0	0	„	160/-

Tin (English ingots)

	£	s.	d.		
Aug. 8 ..	233	15	0	dec.	5/-
„ 9 ..	229	10	0	„	85/-
„ 12 ..	223	10	0	„	120/-
„ 13 ..	219	10	0	„	80/-
„ 14 ..	211	10	0	„	160/-

Spelter (ordinary)

	£	s.	d.		
Aug. 8 ..	14	7	6	inc.	3/9
„ 9 ..	14	6	3	dec.	1/3
„ 12 ..	14	6	3	No	change
„ 13 ..	14	6	3	„	„
„ 14 ..	14	6	3	„	„

Spelter (Electro, 99.9 per cent.)

	£	s.	d.		
Aug. 8 ..	17	0	0	inc.	3/9
„ 9 ..	16	18	9	dec.	1/3
„ 12 ..	16	18	9	No	change
„ 13 ..	16	18	9	„	„
„ 14 ..	16	18	9	„	„

Zinc Sheets (English)

	£	s.	d.		
Aug. 8 ..	22	10	0	inc.	7/6
„ 9 ..	22	10	0	No	change
„ 12 ..	22	12	6	inc.	2/6
„ 13 ..	22	12	6	No	change
„ 14 ..	22	12	6	„	„

Lead (English)

	£	s.	d.		
Aug. 8 ..	17	10	0	No	change
„ 9 ..	17	10	0	„	„
„ 12 ..	17	10	0	„	„
„ 13 ..	17	15	0	inc.	5/-
„ 14 ..	17	15	0	No	change

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1901	8 0 0	7 10 0	7 5 0	7 0 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 15 0	6 17 11
1902	7 0 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 13 4
1903	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 7 0	6 5 0	6 9 4
1904	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 2 11½
1905	6 5 0	6 5 0	6 0 0	5 17 6	5 15 0	5 15 0	5 15 0	5 15 0	6 0 0	6 5 0	6 15 0	6 15 0	6 1 10½
1906	7 0 0	7 5 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	6 10 0	6 12 6	6 16 3	7 3 9	6 17 8
1907	7 3 9	7 5 0	7 5 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 0 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 2 6	6 0 0	6 10 0
1909	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9½
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 7 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 0
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 0
1913	8 11 6	8 10 7½	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	6 18 1½	6 17 6	7 16 9
1914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 9	7 12 6	7 5 7½	7 6 3	7 1 0
1915	7 11 6	8 5 11	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0
1916	13 7 6	13 10 8	13 12 9½	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 3 9½
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0
1918	13 15 0	13 17 3	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 5½
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 7 6	22 12 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 3½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 6	12 6 2½
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 19 0	12 0 2
1927	12 6 3	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	10 12 6	10 5 0	9 16 0	9 15 0	9 13 9	9 12 9	10 14 2
1928	9 12 6	9 12 6	9 11 0	9 10 0	9 8 4	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 3 6	9 1 3	9 7 0
1929	9 0 0	9 2 6	9 5 7½	9 9 4½	9 10 0	9 17 6	10 2 6	10 2 6	10 2 6	10 0 6	10 3 9	10 5 7	9 15 2½
1930	10 7 6	10 7 6	10 7 6	10 6 10½	10 6 3	10 5 0	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 4 7½
1931	10 2 6	10 0 0	10 0 0	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 16 10½	9 18 0½
1932	9 15 0	9 15 0	9 15 0	9 15 0	9 13 9	9 11 3	9 10 0	9 10 0	9 10 0	9 6 3	9 5 0	9 5 0	9 10 11½
1933	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0
1934	9 5 0	9 8 1½	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 11 6
1935	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	—	—	—	—	—	—

* No quotation available owing to strike.

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